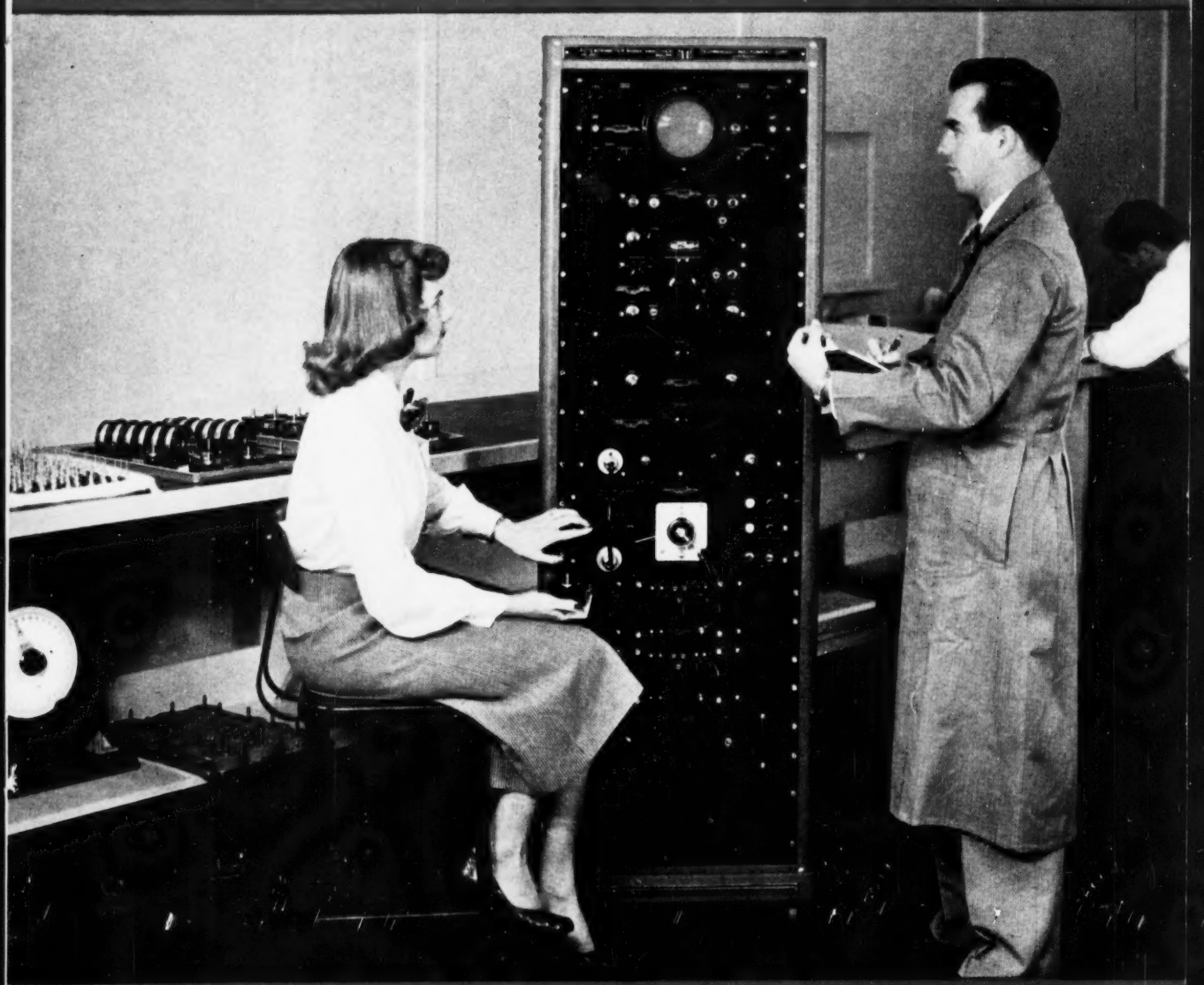
Instruments

THE MAGAZINE OF MEASUREMENT
INSPECTION · TESTING · CONTROL



Potentiometer Noise Analyzer (see story on page 1712).

Including the
JOURNAL OF THE INSTRUMENT SOCIETY OF AMERICA (Page 1719)

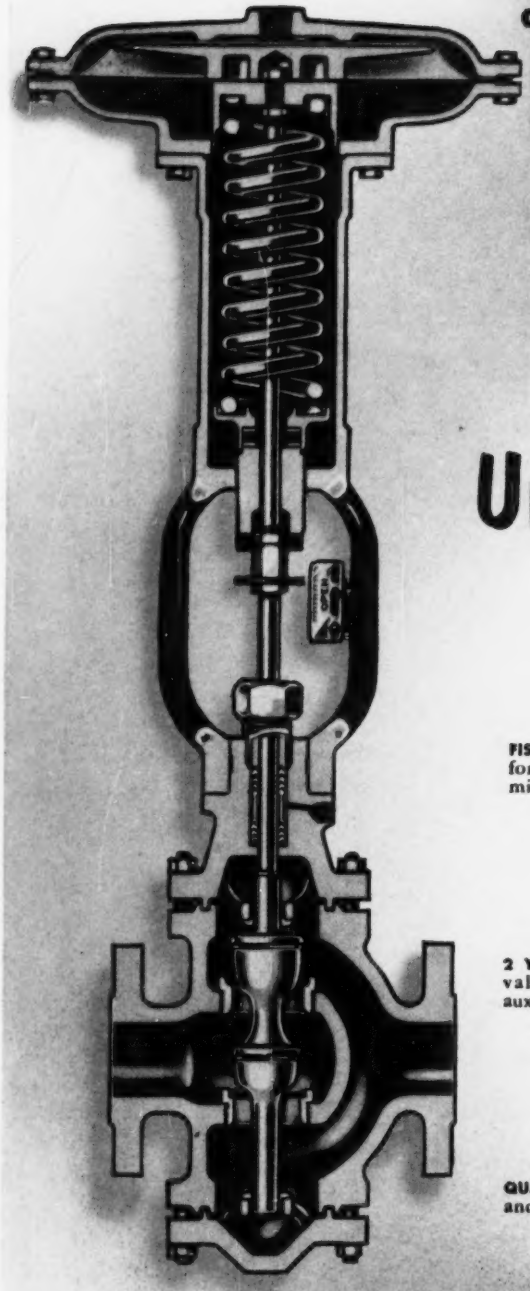
and the
JOURNAL OF THE SOUTHERN CALIFORNIA METER ASSOCIATION (Page 1721)

Vol. 26 No. 11
NOVEMBER • 1953

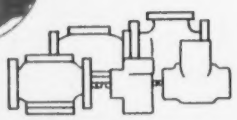
Exclusive features of design plus quality controlled materials and workmanship are the reasons

FISHER®

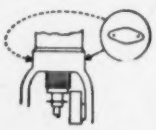
Diaphragm Motor Valves are Universally Preferred



FISHER ALLOY SPRINGS are tested for load tolerances of plus or minus 2½%.



VARIETY OF BODY TYPES and materials—iron, steel, bronze, alloys, single and double seated, angle and globe.



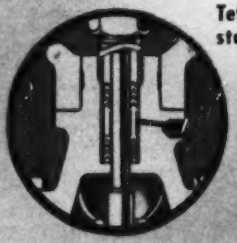
2 YOKE MOUNTING PADS for valve positioner and other auxiliary equipment.

WIDE CHOICE OF INNER VALVES to provide desired flow characteristics.

QUALITY CONTROLLED materials and workmanship.

WALL SECTIONS conform with ASA fittings code.

Fisher offers the most versatile and complete line of Diaphragm Motor Valves—manufactured to handle pressure conditions up to 6,000 pounds. Available in metals for highly corrosive service and alloys for high temperature work. They are built for your specific requirements.



VERSATILE! ECONOMICAL!

Teflon V-Ring Packing, requiring no lubrication, is standard on all Fisher Diaphragm Motor Valves

Dual Teflon packing also available. 2 sets of packing separated with bleed area where purge zone is desired. Positively prevents outbound leakage—or inbound leakage under vacuum service. For dangerous toxic, corrosive, etc. applications.

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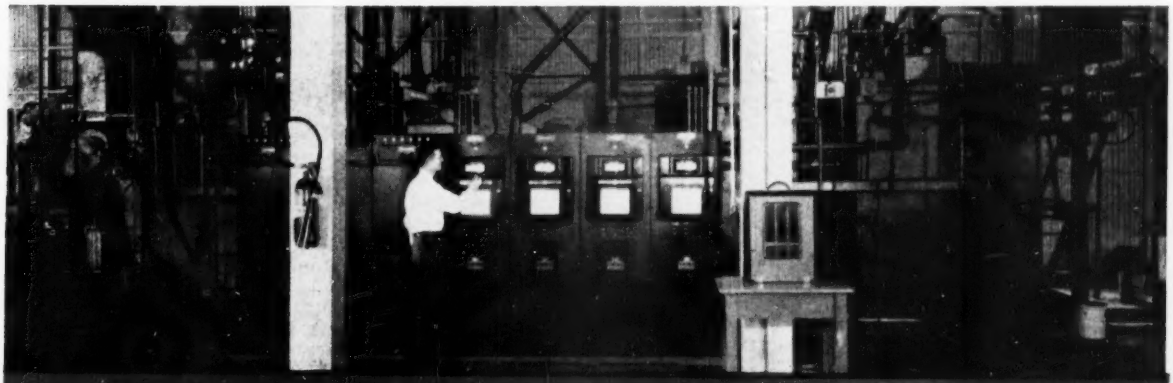
For more information circle 1 on inquiry card.

BARBER COLMAN

Wheelco Instruments

...make temperatures behave in LINE MATERIAL CO.'s automatic heat treat unit!

Imagine, if you will, a heat treating department as clean, efficient and continuously operating as a hydroelectric plant! At Line Material Company's Southern plant, M-1 Garand rifle barrels are automatically loaded, hardened, quenched, tempered and unloaded at the rate of 165 an hour in this new, conveyorized heat-treating unit, with automatic time cycle controls. Only a few process engineers and operators are required to check and operate the furnaces. Wheelco Instruments give them a continuous, accurate report on the heating process . . . control temperatures precisely to produce uniform physical properties and minimize straightening operations. For continuous or batch-type heating operations, Wheelco Instruments will give you better, more accurate automatic control!



One of six such heating installations constructed by the **Lindberg Engineering Company**—this automatic heat treat unit is equipped with a battery of four Wheelco Capacilogs to indicate, control and record furnace temperatures . . . four Wheelco Throttletrols to automatically vary fuel input . . . and four Wheelco Flame-otrol Combustion Safeguards to assure safe-start, safe operation and safe shut-off!

Checking the record—Mr. George Harris—in charge of heat treating at Line Material Company's Birmingham, Alabama, plant—checks the strip chart record showing straight *hairline* control produced by Wheelco Capacilogs.

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☐ Indicating Pyrometers ☐ Controllers ☐ Recorders
☐ Combustion Safeguards ☐ Thermocouples and Accessories

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Firm Name_____

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For more information circle **2** on inquiry card.

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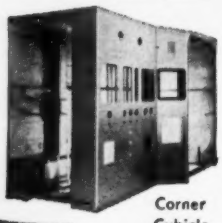
and CONTROL BOARDS

Benchboard Console



Five Section Cubicle Control Board and Lighting Canopy

Corner Cubicle Section

Refinery Cubicle with Mimic Flow Diagram in Color

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Experienced designing and quality fabrication assure the efficiency of any indicating, recording, or control installation. Whether you are planning new construction, modernizing existing installations or adding to present equipment, FALSTROM offers long years of experience and the most modern facilities for fabricating to your specifications or recommending standard designs. In any case, by specifying FALSTROM you specify the highest possible quality metal working techniques known to the industry. Estimates on your needs will be supplied promptly—call or write FALSTROM to arrange a consultation.

WRITE FOR BULLETIN #125

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DESIGNERS, ENGINEERS AND BUILDERS OF CUSTOM METAL PRODUCTS FOR INDUSTRY

For more information circle 3 on inquiry card.

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LEWIS

RESISTANCE THERMOMETER AND ACCESSORIES

The Model 62 RT4F Resistance Thermometer is a sturdy, easy to read instrument with a six inch hand drawn scale. It is suitable for use in moving vehicles, is excellent for flight testing or for permanent panel installations. Operated by an ordinary dry cell and calibrated to standard "AN" bulb curves, this instrument is ideal for use with any of the resistance bulbs illustrated below. Other ranges available in °C or °F.

ACCESSORIES — RESISTANCE BULBS AND SWITCHES

Lewis Selector Switches have been used for years in automotive test work as well as in permanent installations. Simple, sturdy construction plus finest materials combine to give long service.

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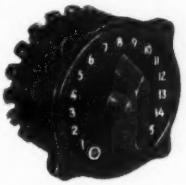
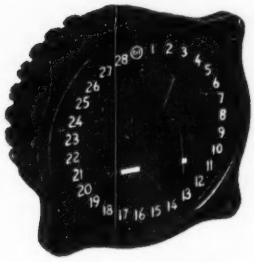
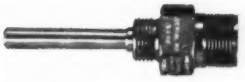


3" SIZE TO 20 POINTS



4" SIZE TO 28 POINTS

FREE AIR



THREADED "AN" TYPE

THREADED "AN" TYPE

BAYONET TYPE FOR CYLINDER HEAD TEMPERATURE

Lewis Resistance Bulbs are adaptable for use with the 62RT4F Resistance Thermometer or with standard aircraft panel indicators. Special purpose bulbs with stem variations or for high temperature applications are available.

We invite inquiries on your temperature measuring problems.

THE LEWIS ENGINEERING CO.

Manufacturers of *Complete* Temperature Measuring Systems for Aircraft

NAUGATUCK, CONNECTICUT

For more information circle **4** on inquiry card.

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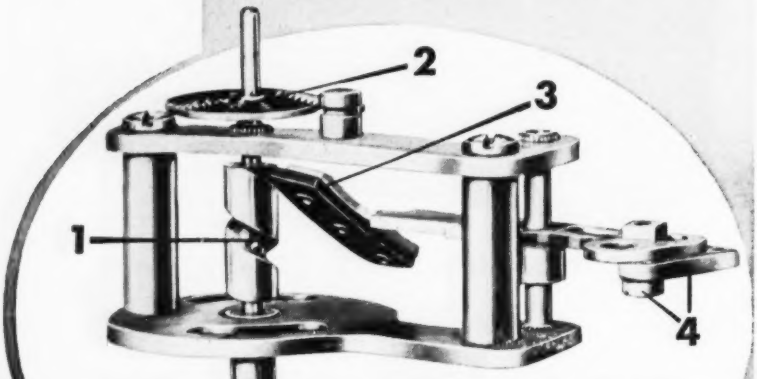
The greatest achievement of the gage makers' craft—pressure gages without gears. The Helicoid movement... tested and proved in years of hard service ... is a simple cam and roller arrangement that gives long, trouble-free service.



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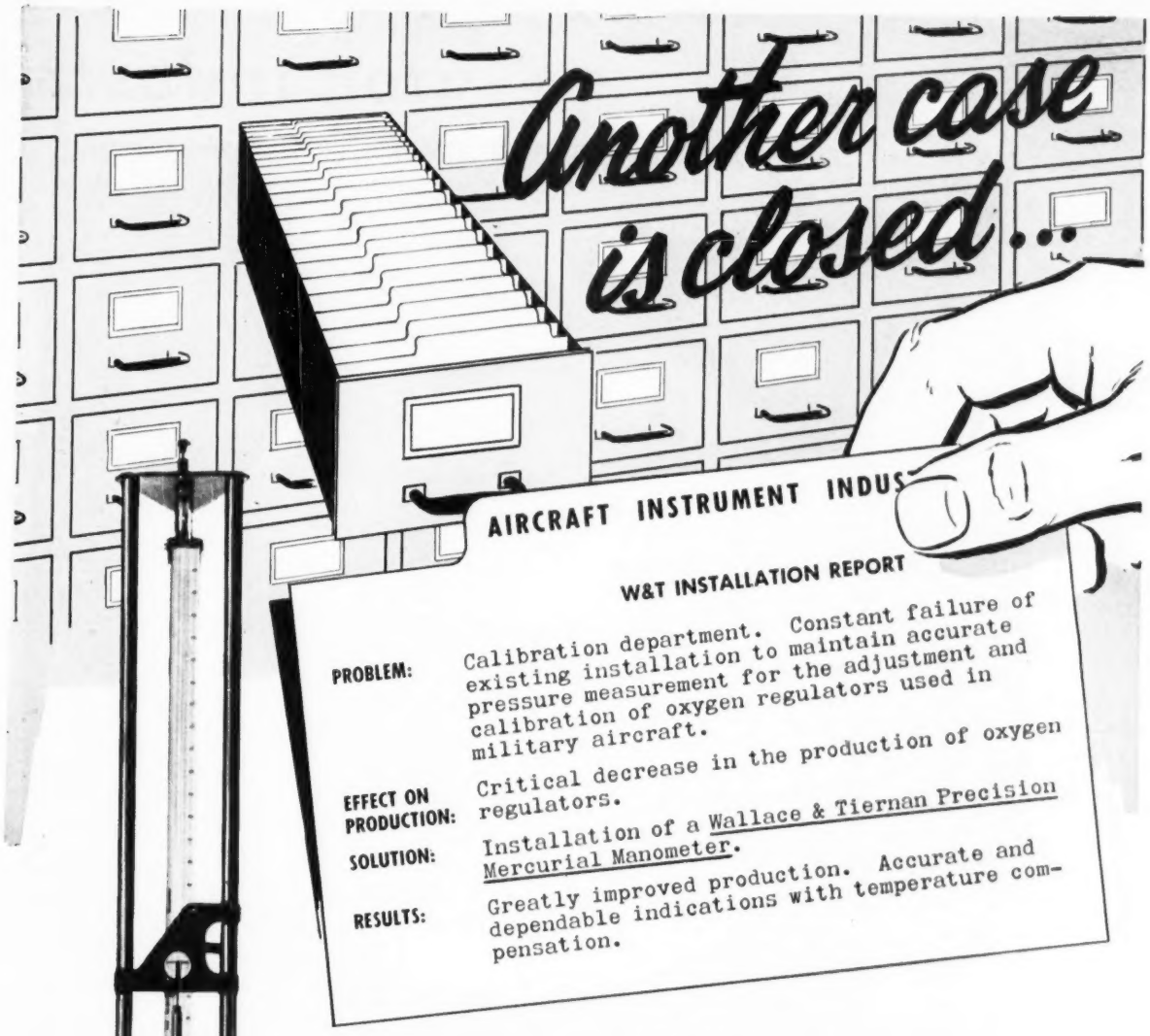
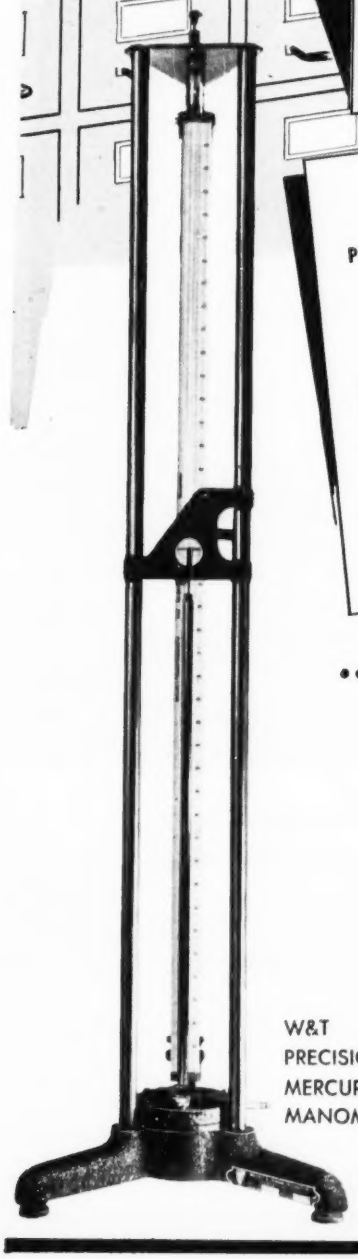

Another case is closed...
AIRCRAFT INSTRUMENT INDUS
W&T INSTALLATION REPORT
PROBLEM: Calibration department. Constant failure of existing installation to maintain accurate pressure measurement for the adjustment and calibration of oxygen regulators used in military aircraft.
EFFECT ON PRODUCTION: Critical decrease in the production of oxygen regulators.
SOLUTION: Installation of a Wallace & Tiernan Precision Mercurial Manometer.
RESULTS: Greatly improved production. Accurate and dependable indications with temperature compensation.



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...Thanks to a W&T Precision Instrument

FEATURES:

- **Scales are made with a precision dividing machine**
- **Precision bore tubing provides accuracy with interchangeability**
- **Float type indicator eliminates difficulty in reading meniscus**
- **Mercury-sealed valve permits evacuating the tube easily and quickly**

If you have a problem in the measurement or control of pressure, write today for additional information.

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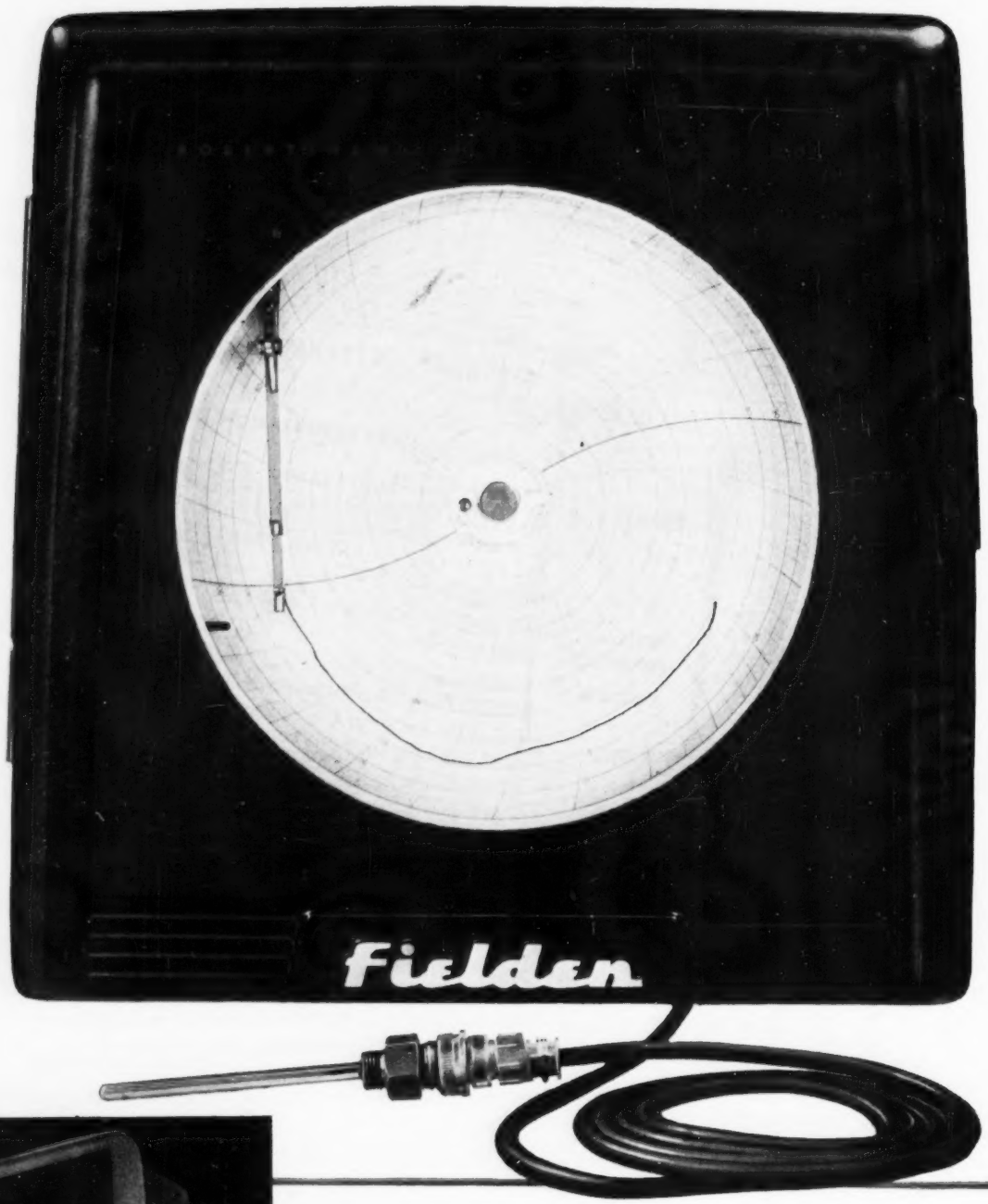
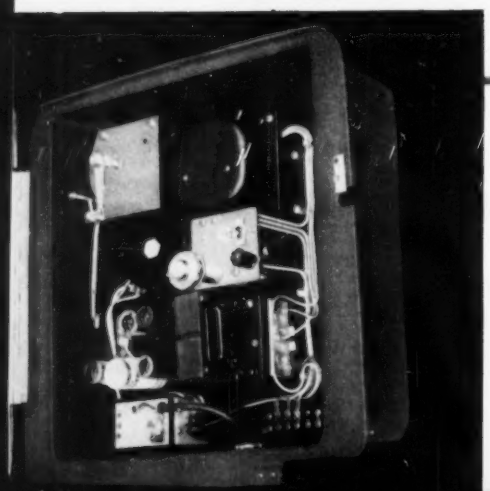




Note Absence of Complex, Costly Mechanisms In Electronic Chassis

Simple, sturdy, unitized construction with few units. Low initial cost and easy, inexpensive maintenance. The electronic chassis is compact, with components operating well below their ratings ensuring long service. An AC actuated bridge circuit eliminates direct current source and replacement of dry cells. The complete unit can be changed in a few minutes—and a spare chassis can be supplied for use as a stand-by.

For more information circle **7** on inquiry card.

instrumentation?

fielden says YES—

when you're paying for *sophistication.* This is the hyper-accuracy and fancy features you rarely need—yet these can multiply your instrumentation costs. For most applications, the new Fielden concept of *simplified instrumentation provides all the essentials*—at a realistic price.

Here is a practical case in point . . .

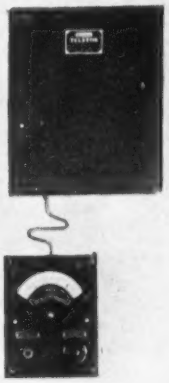
New Fielden Resistance Thermometer Recorder

This new Fielden self-balancing type recorder measures temperature up to 600°F. with an inherent accuracy of ± 0.5% of full scale. It measures spans of 50°F. or less if required—with linear scale on all spans up to 600°F. Interchangeable bridge units permit change in range and type of measurement without rewiring. Up to 4 simultaneous inputs allow addition, subtraction or averaging.

Other Examples of Fielden Simplified Instrumentation

TELSTOR

Electronic Level Indicator



Circuitry is simplicity itself and only 1 vacuum tube is employed. Yet TELSTOR measures continuously—with accuracies to ±2%—the levels of liquids, divided solids or interface. Readings can be recorded up to and over 1 mile. Maintenance is easy—no floats to stick or leak—no pneumatic or hydraulic tubing. Cost is gratifyingly low.

TEKTOR

Electronic Level Control

Provides level control as close as 1/16" of any material that flows—liquid, divided solid or interface—conducting or non-conducting—wet or dry. Can also be used for accurate indication. No moving parts—only 1 radio tube. Simple failsafe, high-or-low-level control circuit operates visual or audible alarms, motor starters, solenoid valves, timers. Low initial cost—easy installation.

TEKTOLOG

Electronic Recorder

Accurate to ±1% of full scale, yet has simplified design—only 4 principal units. Self-starting operation, directly from low energy sources, with various recording speeds to suit applications. Available with electric or pneumatic controls. Supplied as portable or industrial unit—easily installed by flush or surface mounting. Dust-tight, weather-proof case prevents deterioration by atmospheric or other conditions.

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Company _____

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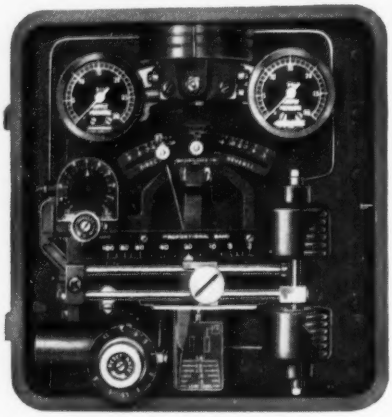
City _____ State _____

For more information circle **7** on inquiry card.

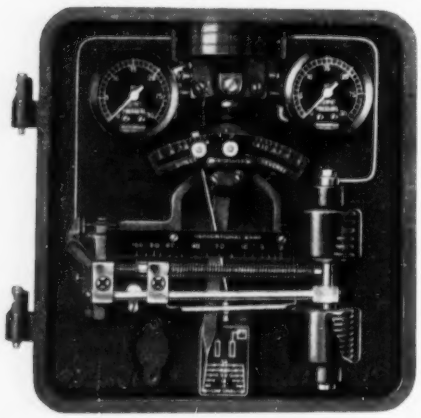
6 Reasons

Wide range of selection of the basic controller unit to fit your application is represented by the five single-unit controllers illustrated below . . . five of the many reasons why Masoneilan Liquid Level Controllers offer you more for your money. The sixth is the convenience of grouping any two of these in one case as illustrated in the model to the right. This range of selection enables you to obtain from *one* manufacturer the control equipment for almost any liquid level application.

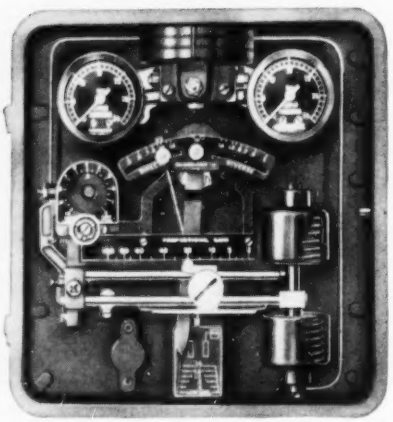
Model 12800 — The basic proportional controller; may also be used as a transmitter; may be converted in the field to a differential gap controller.



Model 12810 — Adds reset action to the proportional controller. Conversion of Model 12800 may be accomplished in the field if desired.



Model 12820 — The pneumatic transmitter provides an output air signal which is proportional to level changes, for indication, recording or control.

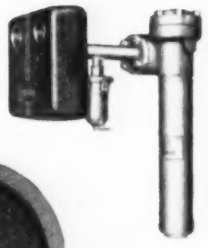


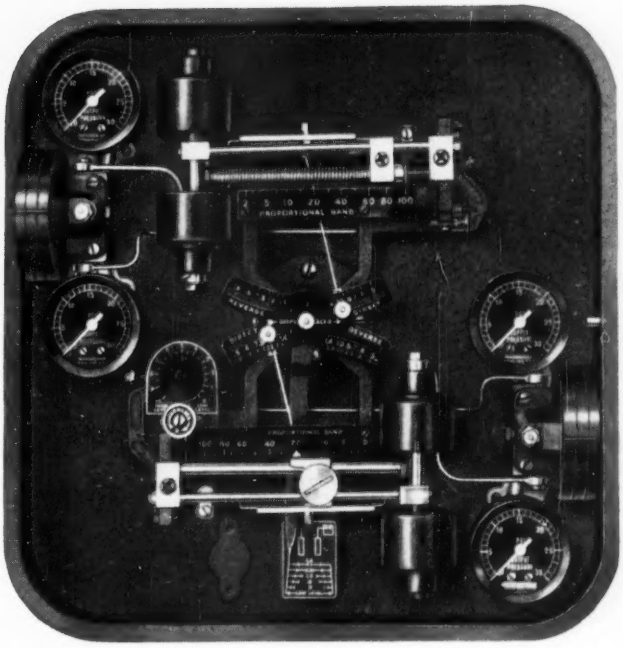
Model 12830 — The differential gap controller. May be converted to a proportional controller in the field if process changes require it.

TWENTY POSSIBLE

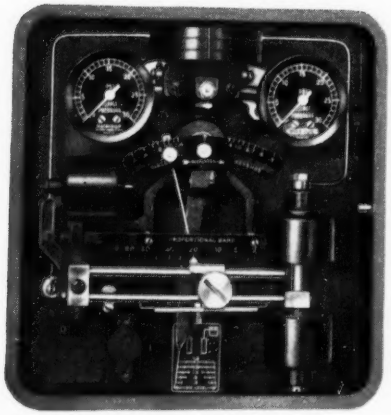
For more information circle 8 on inquiry card.

→ Why You Should Select Masoneilan Level Controllers





Model 12800-20 — A duplex model grouping the proportional controller and pneumatic transmitter. Any combination of two identical or dissimilar single units is possible — a total of fifteen combinations.



Model 12840 — The pneumatic set controller provides for remote adjustment of set point. Available with either proportional or proportional-reset action.

Simplicity of design; sensitive accuracy of control; wide choice of materials; ease of maintenance; convenience of installation; and sturdy, long lasting construction are six *other* reasons why you should select Masoneilan 12000 Series Liquid Level Controllers.

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INSTRUMENT COMBINATIONS

For more information circle **8** on inquiry card.

what eyes! what hands! Human eyes and hands are expensive!

The Benson-Lehner Electroplotter eliminates the slow, tiring process of manual plotting and enables you to increase the productivity of your entire operation. Fast, accurate, and flexible, the Electroplotter takes information from a keyboard and a variety of analog and digital devices and converts it into a meaningful form for technical and management personnel.

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Name Your Flow Metering Problem . . .

Here's the Solution!

Difficult metering jobs — formerly so "impossible" to maintain as to be abandoned or not even attempted — have proved to be successful routine operations with the Foxboro d/p Cell. Here are just a few typical examples:

CORROSION

Corrosive fluids such as fuming nitric acid, SO_2 and dry Cl_2 can be handled without seals or purges, by the all-316 stainless steel construction of the d/p Cell. For materials which attack 316 stainless steel, the negligible displacement (3cc) of the d/p Cell permits use of liquid seals without seal pots, or loss of seal fluid due to pumping. Successful installations include mercury sealing of anhydrous HF, and oil sealing of 30% H_2SO_4.

FREEZING

Flowing fluids that freeze at ambient temperatures can be metered without difficulty by the d/p Cell. Its unique construction permits simple steam tracing or electric heating of the cell body and meter leads to maintain fluid conditions. Accurate metering of naphthalene for ratio flow control with oxygen in the production of phthalic anhydride is typical of numerous services for which d/p Cells are currently employed.

SLURRIES

Most slurries can be metered directly in the d/p Cell. For the more concentrated types, a small liquid purge (one liter per hour) maintains the cell free of deposit. Lime and phosphate slurries and 4½% paper pulp are typical of many materials now being handled.

COAGULATION

Plugging of meter lines by materials that coagulate or polymerize is held to a minimum by the small displacement of the d/p Cell. On synthetic rubber latex, for example, reliable metering has been obtained; production downtime for instrument maintenance has been practically eliminated; and routine clean-out time has been reduced 87%! (Details given in Rubber Reserve report available from Foxboro.)

For your simple, "everyday" jobs of metering steam, water, hydrocarbon and other common fluids, the d/p Cell offers equally important advantages. Its light weight and simple piping make installation easy and economical . . . its sturdy, simple design practically eliminates maintenance. Write for detailed information on the d/p Cell or its application to your particular problem.

THE FOXBORO COMPANY, 4611 NEPONSET AVE., FOXBORO, MASS., U.S.A.

FOXBORO REG. U.S. PAT. OFF. **d/p cell**

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

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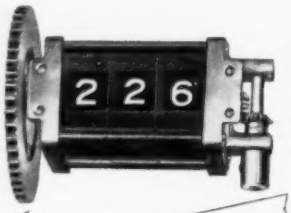

Small Component... or Complete Unit... You* can count on getting whatever You* need—

Added Evidence that—

Everyone Can Count on VEEDER-ROOT

This REEL CONTROL BOX, complete with its *built-in* counting mechanism, indicates the number of feet of antenna reeled in and out of certain types of military aircraft. Manufactured completely by Veeder-Root, including outside bakelite cover and box, this unit shows another imaginative application of the universal language of direct-reading *Count*rol.

Now if you, *in any of your defense work,** have a counting problem, then you can count on Veeder-Root to help you in every possible way.

VEEDER-ROOT INCORPORATED
"The Name That Counts"
HARTFORD 2, CONN. • GREENVILLE, S.C.
Montreal 2, Canada • Dundee, Scotland
Offices and agents in principal cities

"Counts Everything on Earth"

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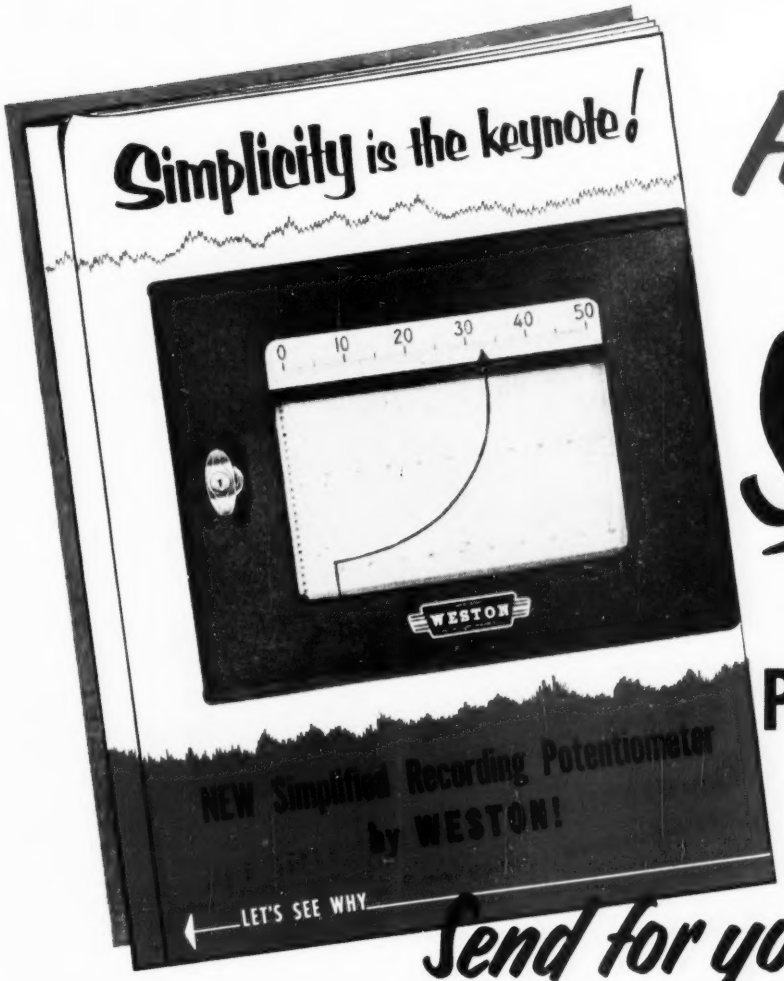


Full Data on the new Simplified Recording Potentiometer

Send for your copy!

This booklet unfolds the complete story of the recording potentiometer that has been acclaimed by instrument men everywhere for its unequalled versatility, accuracy, long-term dependability, and its *unit design* which makes servicing so simple and quick.

With fewer components . . . with all assemblies greatly simplified and quickly interchangeable . . . with all adjustments including range changes made quickly on the line . . . with new ruggedness to withstand vibration, shock and usual plant abuse . . . it has set new standards for sustained accuracy, and for economy in servicing and maintenance.

This new WESTON Simplified Recording Potentiometer can be used to measure and record temperature, d-c current, d-c voltage, resistance, a-c voltage, a-c current, speed, speed ratio, power, frequency, hydrogen ion (pH), light intensity or any other quantity that can be converted into electrical values. The whole story is available in this booklet. Send coupon for your copy today. WESTON Electrical Instrument Corporation, 614 Frelinghuysen Avenue, Newark 5, New Jersey.

WESTON

4812

WESTON *Instruments*

WESTON ELECTRICAL INSTRUMENT CORPORATION
614 Frelinghuysen Avenue
Newark 5, New Jersey

Send a copy of the booklet describing the WESTON Simplified Recording Potentiometer to:

NAME_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____

For more information circle **12** on inquiry card.

STANDARD PRECISION TIMERS

Part of the Picture

STANDARD

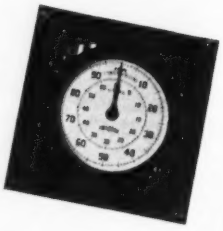
ESTABLISHED

1884

TIME AFTER TIME . . . in centralized control systems, and in scores of other places where the precise measurement of elapsed time is of the utmost importance, you will be sure to find Precision Timers by

STANDARD

STANDARD ELECTRIC'S *precision timer is an important component of the nuclear reactor control room (shown below) at Brookhaven National Laboratory . . . as is the* STANDARD ELECTRIC *experimental patchboard in the Brookhaven chemistry laboratory.*



The STANDARD ELECTRIC TIME CO.

93 Logan Street • Springfield 2, Massachusetts

LABORATORY PANELS
PIPELINE NETWORK ANALYZERS

PRECISION TIMERS
CHRONO-TACHOMETERS

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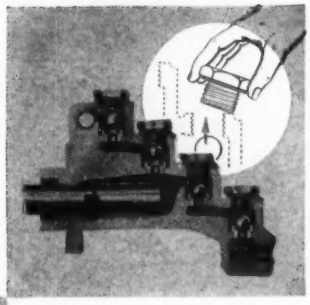
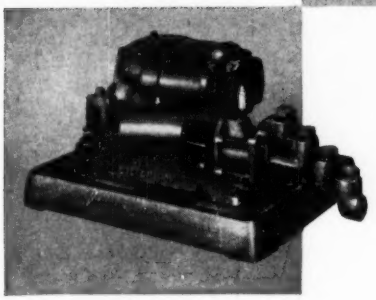


Basic design simplicity of the *exclusive* Milton Roy liquid end step-valve assures high and reproducible volumetric efficiency. Inspection, servicing, or thorough cleaning of individual ball-checks and seats are effected without disturbing piping or other ball-checks and seats.



Two-to-One Service Life with this Milton Roy Pump

CONTROLLED VOLUME PUMPING

INSTRUMENTATION

PROCESS CONTROL SYSTEMS

BLENDING AND FORMULATING

ON THE JOB for a leading chemical manufacturer, this Milton Roy Motor-Driven Controlled Volume Pump is still going strong after 4½ years of operation . . . has needed very little maintenance. A previously employed chemical feed pump, on the other hand, lasted only 2½ years, and required considerable maintenance.

Long service life is just one of many reasons why rugged Milton Roy Pumps are in wide use throughout industry. Wherever requirements call for precise metering of measured quantities of liquid in controlled volume, there's one of these versatile instruments to do the job. Capacity of each pump is variable from 0 to 100% by any one of several mechanical or automatic means of plunger stroke or speed adjustment.

Driven by motor, or powered by air, Milton Roy Pumps meter practically any liquid . . . in capacities from 3 milliliters per *hour* to 45 gallons per *minute*, against pressures up to 25,000 pounds per square inch. They are available as single or multiple units or as component parts of complete chemical feed and control systems. We invite your inquiries.

***New Bulletin No. 553** tells the complete story on Milton Roy Motor-Driven Controlled Volume Pumps and their application. Write for your **free** copy.*

Engineering Representatives in the United States, Canada, Mexico, Europe, Asia, South America and Africa.

MILTON Roy COMPANY

Manufacturing Engineers 1300 E. MERMAID LANE • PHILA. 18, PA.

CONTROLLED VOLUME PUMPS AND AUTOMATIC CHEMICAL FEED SYSTEMS

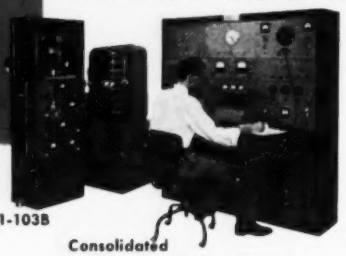
For more information circle **14** on inquiry card.

World leadership in mass spectrometers

Model 21-201

Consolidated-Nier Isotope-Ratio Mass Spectrometers

For high-precision isotope-ratio measurements; medical, biological and chemical tracer experiments; cancer and metabolism research; catalytic studies; geological assays.



Model 21-103B

Consolidated Analytical Mass Spectrometer

For fundamental research in petroleum processing, chemical manufacturing, biochemical and molecular-structure investigations.

Model 21-401

Dual-Purpose Analytical Isotope-Ratio Mass Spectrometer

Provides both analyses of gaseous or light liquid mixtures *and* precise, recorded ratios of stable gaseous isotopes.

Model 21-610

Process Monitoring Mass Spectrometer

Meeting high standards of accuracy and sensitivity, this instrument delivers continuous, unattended service for analysis, process control, leak detection.

Model 24-101A

Mass Spectrometer Type Leak Detector

Portable, extremely sensitive; locates leaks in vacuum equipment, high pressure cylinders, compressor units, glass-to-metal seals, and welded joints.

Typical users

Allied Chemical & Dye Corporation
American Cyanamid
American Steel & Wire Company
Argonne National Laboratories
Armour Research Foundation
Atlantic Refining Company
Atomic Energy Commission
Bell Telephone Laboratories
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Brookhaven National Laboratory
Brown, Boveri Company, Switzerland
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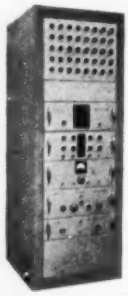
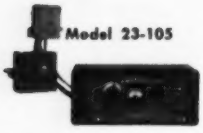


Model 23-105



Consolidated's Micromanometer

For absolute, high-accuracy micron pressure measurements, independent of gas composition. Range 0.1 to 150 microns, readable to 0.1 micron.

Consolidated's Spectro-Sadic

For high speed digital tabulation. Provides automatic programming of mass spectrometer; tabulates information onto IBM cards or electric typewriter.

Model 30-103

Electrical Computer

Solves linear simultaneous equations; mass and infrared spectrometer analyses; electrical circuits, structures, aircraft flutter and statistics.

Ask for Bulletin CEC-1302-X6

Consolidated Engineering
CORPORATION

300 North Sierra Madre Villa, Pasadena 15, California

Sales and Service through **CEC INSTRUMENTS, INC.,** *a subsidiary with offices in: Pasadena, New York, Chicago, Washington, D. C., Philadelphia, Dallas.*

analytical instruments for science and industry

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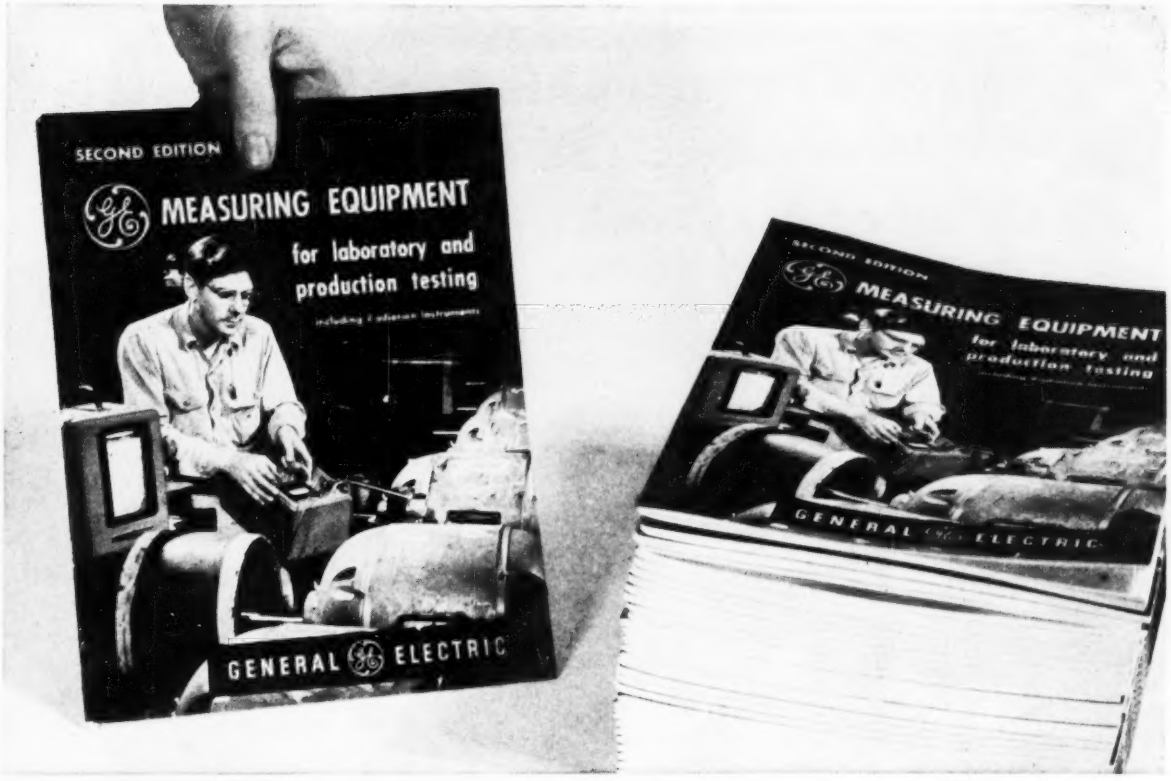

New Revised Edition Now Available . . . .

G-E Measuring Equipment Catalog

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117 DIFFERENT DEVICES for production and laboratory testing are described and shown in this new catalog.

Send today for your free copy of this 64-page catalog containing up-to-date condensed information about all G-E Testing and Measuring Equipment.

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General Electric Co.
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Please send me GEC-1016A, Catalog of General Electric Measuring Equipment for laboratory and production testing.

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GENERAL ELECTRIC

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Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters

Here is Why!

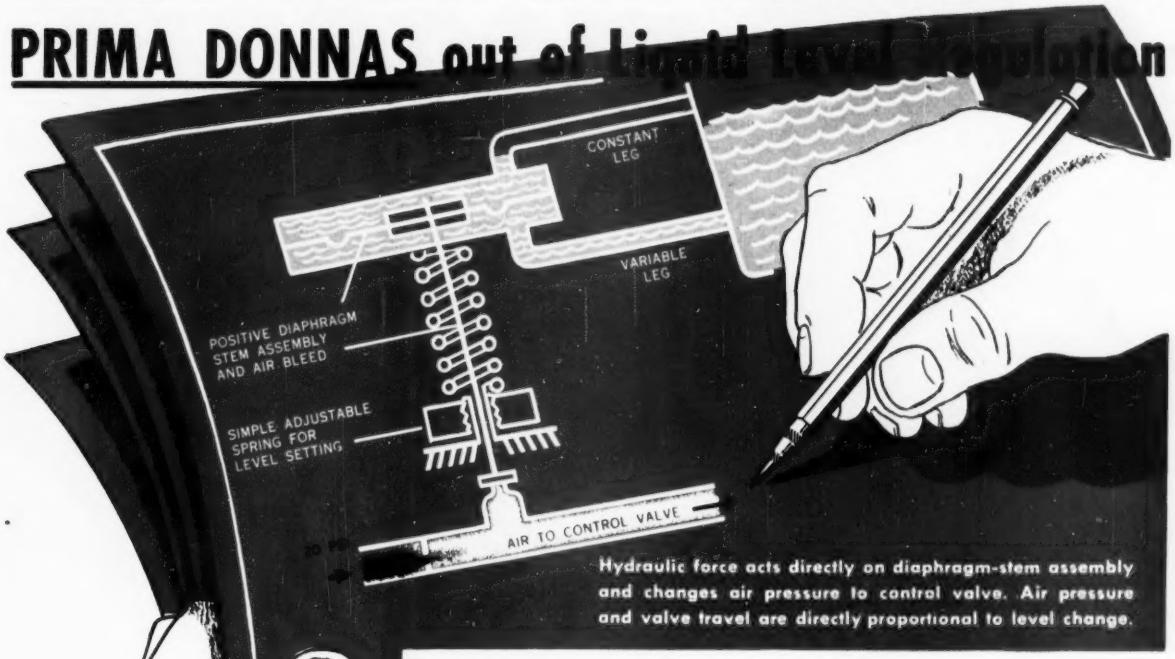
You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

- No oil filters.
- No dust filters.
- No internal lubrication to contaminate air handled.
- No internal wearing parts.
- No valves, pistons, or vanes.
- Non-pulsating pressure.
- Original performance constant over a long pump life.
- Low maintenance cost.

NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.

LESLIE *Floatless* Level Control takes the PRIMA DONNAS out of Liquid Level Regulation


CONSTANT LEG
VARIABLE LEG
POSITIVE DIAPHRAGM STEM ASSEMBLY AND AIR BLEED
SIMPLE ADJUSTABLE SPRING FOR LEVEL SETTING
AIR TO CONTROL VALVE

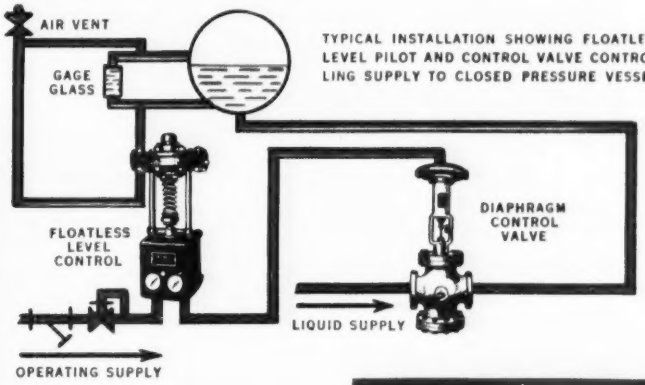
Hydraulic force acts directly on diaphragm-stem assembly and changes air pressure to control valve. Air pressure and valve travel are directly proportional to level change.

Here is level control that is not affected by surface agitation, equipment vibration, or the roll of a ship—a simple design that provides steady, positive, precise control even under extreme conditions.

Thousands are in service today, providing accurate control of liquid level (plus or minus 1″ water column) and eliminating the problems caused by troublesome linkages, torque tubes, floats and stuffing boxes.

Note these special features—

1. **Can be installed anywhere below liquid level . . . on control panel, if desired.**
2. **Simple, compact, one adjustment unit . . . weighs only 40 lbs.**
3. **Diaphragm stem assembly is only moving part. Diaphragm element doesn't require recalibration during service.**



TYPICAL INSTALLATION SHOWING FLOATLESS LEVEL PILOT AND CONTROL VALVE CONTROLLING SUPPLY TO CLOSED PRESSURE VESSEL

SEND FOR DESCRIPTIVE DATA PC-37

When specifying . . .

Here's *another* LESLIE *standard* item to fit specifications that are *special* orders with most manufacturers. When specifying pressure, temperature or level controls—for new or replacement service—it will pay to check *first* with your nearest LESLIE engineer. He's listed in the classified telephone directory in principal cities . . . under "Regulators" or "Valves"

LESLIE

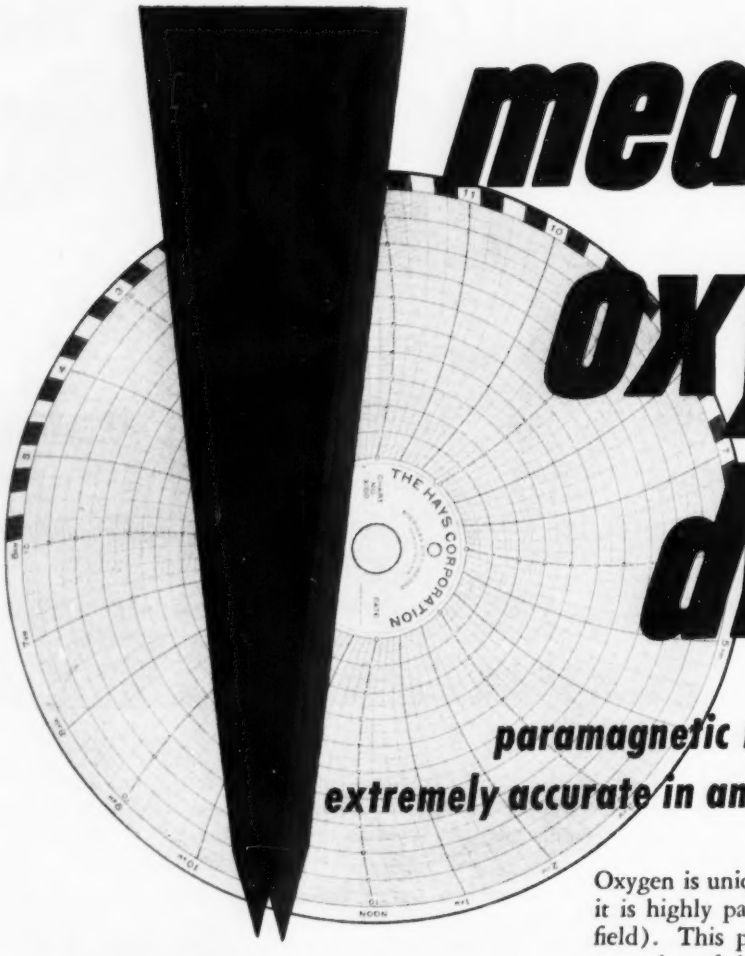
TOPS IN QUALITY PRESSURE LEVEL AND TEMPERATURE CONTROLS
Since 1900

2647

LESLIE CO., 299 Grant Avenue, Lyndhurst, New Jersey

For more information circle 17 on inquiry card.

measure oxygen direct



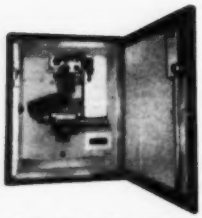
paramagnetic method of measurement extremely accurate in analyzing industrial gases

Oxygen is unique among other common gases in that it is highly paramagnetic (attracted into a magnetic field). This property of oxygen is the basis of the operation of the Hays Magno-Therm Analyzer in the analysis of industrial gases.

application

Hundreds of companies are using the Hays Magno-Therm O_2 Analyzer and Recorder in applications from revivification of SO_2 removers in manufactured gas industry and regeneration of catalysts in oil refineries to mixing air with propane to get substitute fuel. Boiler plants use it as a combustion guide because it is the only means of getting an undistorted picture of excess air.

Write today for bulletin 52-829-56 and get complete details.



ANALYZER

Highly sensitive to changes in oxygen content.

Rapid response to changes in oxygen content.

No liquid or gaseous fuel required to be added to gas sample.

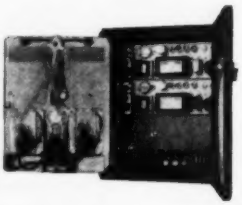
No chemicals required.

High accuracy maintained.

Not affected by wide variation in rate of flow of gas sample.

Rugged construction. No delicate or moving parts.

Easily installed — no special fittings required.



RECORDER

Self-balancing bridge circuit assures accurate, permanent calibration.

Electronic amplifier has no moving parts. High sensitivity. Rugged.

Immediate response—analyzer is continuously connected to recording pen drive motor.

As many as four analyses can be recorded on the same chart.

Range can be changed easily in the field.

Isolating transformer for each amplifier removes line interference from bridge circuit.

Extra slide wire available for control, remote indication—for recorder or contacts for alarm circuit.

Automatic Combustion Control Boiler Panels • CO_2 Recorders Veriflow Meters and Veritrol Gas Analyzers • Draft Gages Combustion Test Sets Electronic Oxygen Recorders Electronic Flowmeters Electronic Feed Water Controls Miniature Remote Indicators

THE hays CORPORATION

MICHIGAN CITY, 8, INDIANA

For more information circle **18** on inquiry card.

How many bolts are required for a perfect seal?

Should it be 10, 14, 18? Where do you stop?
In the patented K & M "Duoseal" design, just two bolts are required.
And you obtain a tight seal . . . not at 10, 14 or 18 points on
the casing . . . but *a continuous seal at infinite points throughout the entire perimeter.* The result: A completely tight, leakproof
seal that actually grows tighter as control pressure increases.
Furthermore, K & M "Duoseal" saves maintenance time with only two bolts
to tighten. This time saving is a particular consideration
when valves *must* be serviced or inspected in the line.
Within the drawn steel diaphragm casing, the K & M molded neoprene
diaphragm provides an extremely large effective area
that is constant throughout the long stem travel. Virtually the highest
"power factor" available results, with more sensitive response
to control pressure variations, more accurate inner valve positioning and
improved flow regulation through the K & M valve body.

***For Complete** Automatic Control Valve Data: Write for your copy of the new K & M Valve Engineering Data Catalog, Bulletin CV53. **Also, Available...** New Valve Size Calculator with Low Flow Data.*

diaphragm control valves

K&M

KIELEY & MUELLER, INC.

Valve Makers
Since 1879

64 Genung Street
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For more information circle **19** on inquiry card.

WHAT'S NEW AT BRISTOL...

Meet the WORLD'S SIMPLEST

It's Bristol's new METAGRAPHIC Pneumatic

for measuring, indicating, recording and controlling pressure, temperature, vacuum, flow, differential pressure, and liquid level

Here are a few of the advantages of Bristol's METAGRAPHIC system:

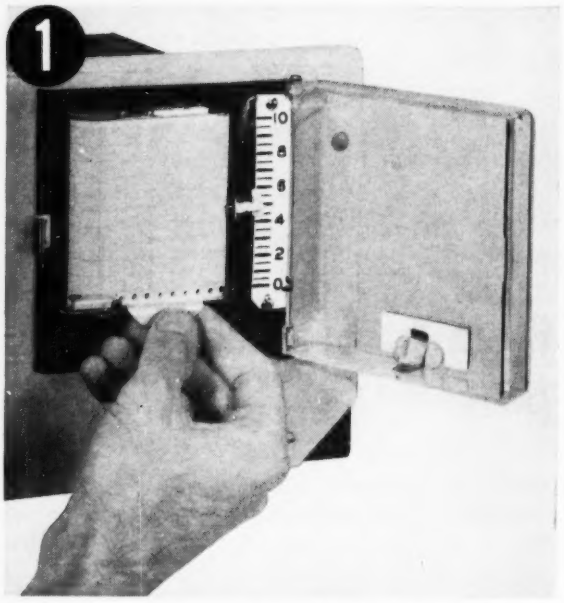
SIMPLICITY... fewer moving parts, fewer adjustments needed, and less service required. Range changes can be made in seconds.

FLEXIBILITY... all components are interchangeable. Units can be combined like building blocks to make up any kind of arrangement; functions can be located exactly where they're needed.

TRUE PLUG-IN SERVICE... provides great savings in installation costs. And if trouble is suspected with any component, just pull the doubtful unit out and plug in a stand-by—*without stopping any processing*. The suspected unit can be taken to the shop and checked whenever time permits. You don't lose any air pressure when changing units, either. Bristol's automatic sealing system prevents loss of signal to other components.

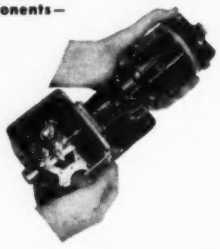
NO TIME LAGS... in a four-pipe circuit the transmitter signal and the controller-output signal travel around a very short loop—which can be as little as three feet long.

These are some of the important advantages of Bristol's METAGRAPHIC instrument system—the product of over 60 years of experience in instrument making and application in practically every industry. Get the whole story by writing to The Bristol Company, 113 Bristol Road, Waterbury 20, Conn.



IT TAKES ONLY SECONDS to change the Bristol METAGRAPHIC receiver from a recorder to an indicator: Case door is opened...

Here are the basic components—



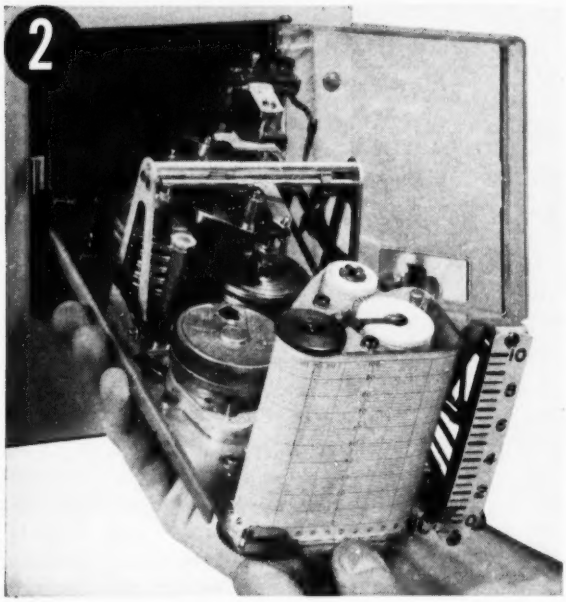
BRISTOL PNEUMATIC TRANSMITTER, with cover removed to show simplicity of the world-famous Bristol measuring element. The frictionless transmitter, with only one pivot and no flexures, will operate in any position, indoors or out. The unit is sensitive to extremely small changes in the measured quantity, as minute as 0.03% of range, including reversal.

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle **20** on inquiry card.

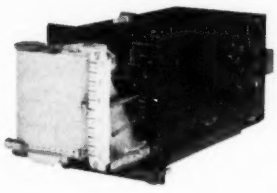
INSTRUMENT SYSTEM!

Transmission instrument system . . .



Recorder chassis withdrawn from case (air pressure is automatically maintained) . . .

Indicator chassis is plugged into same case. Control remains undisturbed throughout change-over.



HERE'S THE RECORDER CHASSIS, in retracted position. Now pen can be inked, set point and zero adjustment made without disturbing record or control. You can bring up to three related variables, such as flow, pressure and temperature, into one receiver. Auto-manual switching is foolproof and "bumpless," without disturbing valve position.

THE BRISTOL CONTROLLER can be plugged into back of receiver, placed at process, or used as a "blind controller." Available in on-off, proportional, proportional plus reset, proportional plus derivative, and proportional plus reset plus derivative. Experienced instrument men will recognize this as a unit service-proved by thousands of installations.*

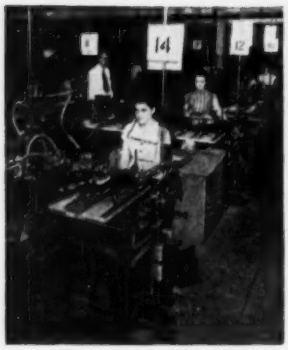
*Licensed under C. B. Moore patents

LOOK FOR OUTSTANDING NEW DEVELOPMENTS FROM BRISTOL

BRISTOL

THE DEPENDABLE GUIDEPOST OF INDUSTRY

For more information circle **20** on inquiry card.

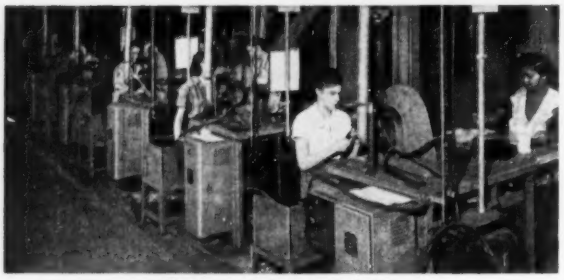


Gas brazing equipment.

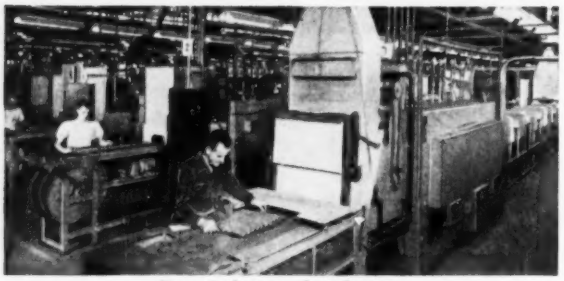
Induction brazing unit.

STOP
YOUR CONTACT TROUBLES
BEFORE THEY START

Hand brazing with oxy-hydrogen torch.



Resistance brazing machines.



Controlled atmosphere furnaces.

Not One...But Five!

All five types of brazing equipment are available at Mallory to meet your particular needs.

On even the simplest button or rivet contact, trouble can start with the wrong method of bonding. Size, shape, nature of the material, frequency and degree of impact, tooling costs and production quantities . . . all must be considered in selecting the one best method of brazing.

Mallory is equipped to make completely unbiased decisions in selecting the best and most economical brazing technique for any type of contact or contact assembly. Our plant is equipped with all five types of brazing equipment . . . as well as four types of resistance welding equipment. Facilities are available in the laboratory as well as on the production floor. Production techniques are worked out ahead of time . . . before production runs are started . . . so you can be sure of completely dependable contacts, economically produced.

This is only part of the story, however. If you want the rest of it, our engineers will be glad to send you complete information . . . or answer any questions you may have regarding the design and production of the contacts for your products.

Expect more...
Get more from MALLORY

In Canada, made and sold by Johnson Matthey and Mallory, Ltd., 110 Industry Street, Toronto 15, Ontario

Electrical Contacts and Contact Assemblies

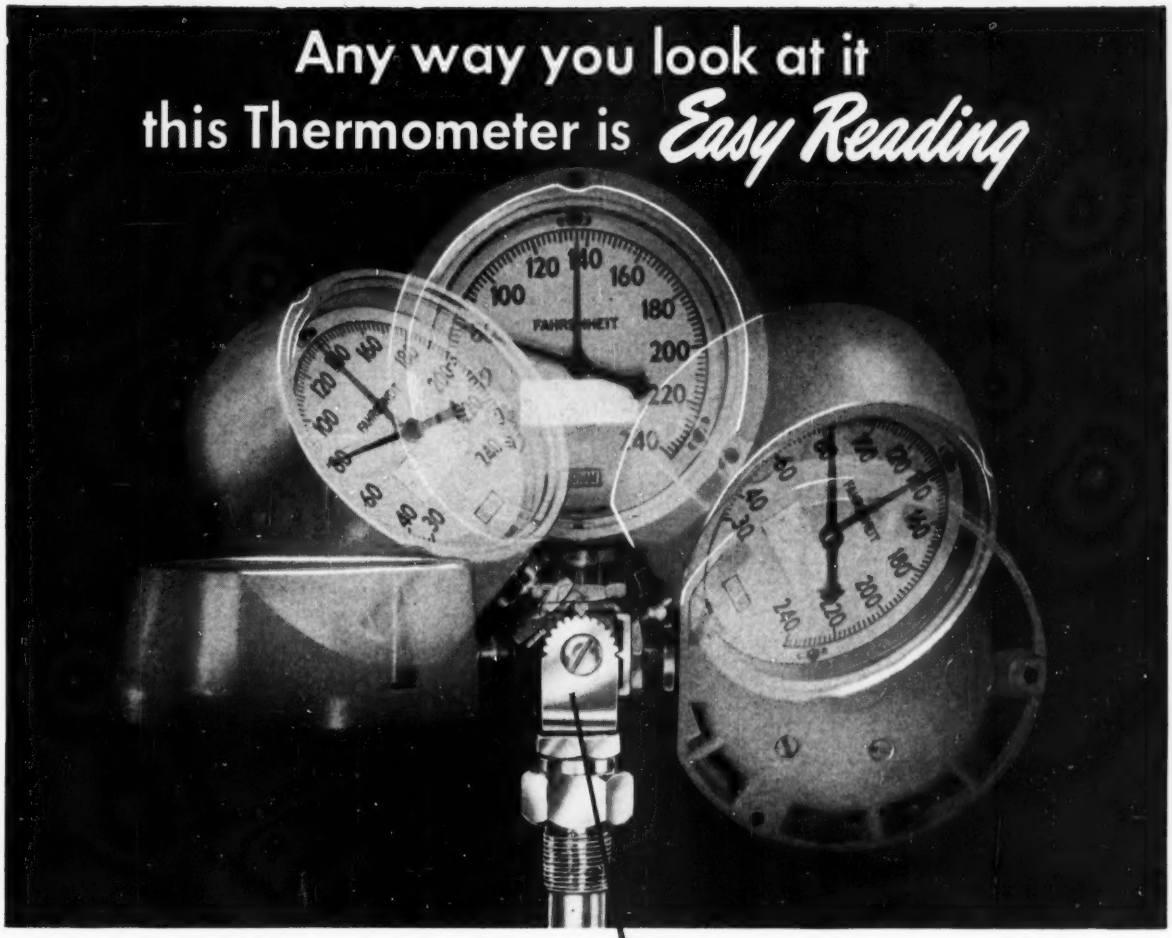
P.R. MALLORY & CO. Inc.
MALLORY

SERVING INDUSTRY WITH THESE PRODUCTS:
Electromechanical—Resistors • Switches • Television Tuners • Vibrators
Electrochemical—Capacitors • Rectifiers • Mercury Batteries
Metallurgical—Contacts • Special Metals and Ceramics • Welding Materials

P. R. MALLORY & CO. INC., INDIANAPOLIS 6, INDIANA

For more information circle **21** on inquiry card.

Any way you look at it this Thermometer is *Easy Reading*



You've been asking for a dial thermometer like this—A thermometer that can be positioned and firmly locked at any practical angle—now you can have it!

No stretching or straining to see this thermometer. Easy to adjust to required new positions before or after installation. No risk of the multi-angle selector working loose. A specially designed selector assures positive locking at every practical mounting angle and a few turns of *one* nut lock the selector securely.

These instruments, supplementing USG's complete line of Gotham temperature indicators, are designed to fit all standard connections and are available in all standard ranges. If you have a number of applications requiring "odd angle" mounting these new multi-angle thermometers will reduce the number and variety of instruments you have to carry in stock.

Before you order an angle thermometer be sure you see USG's new Gotham Multi-Angle Thermometer.

UNITED STATES GAUGE

ADVANTAGES

1. Positive locking in every conceivable angle.
2. Reduces the number and variety of instruments required in your maintenance stock.
3. Provides that extra "odd angle" instrument which normal stock does not furnish.
4. Easy to change to any desired angle, before or after installation.
5. Saves engineers time when writing specifications.
6. Affords easy reading at odd angles.

Dept. 1
United States Gauge
Division of American Machine and Metals, Inc.
Sellersville, Pa.

Gentlemen:

We'd like to know more about the new USG Multi-angle Thermometer. Please get in touch with us.

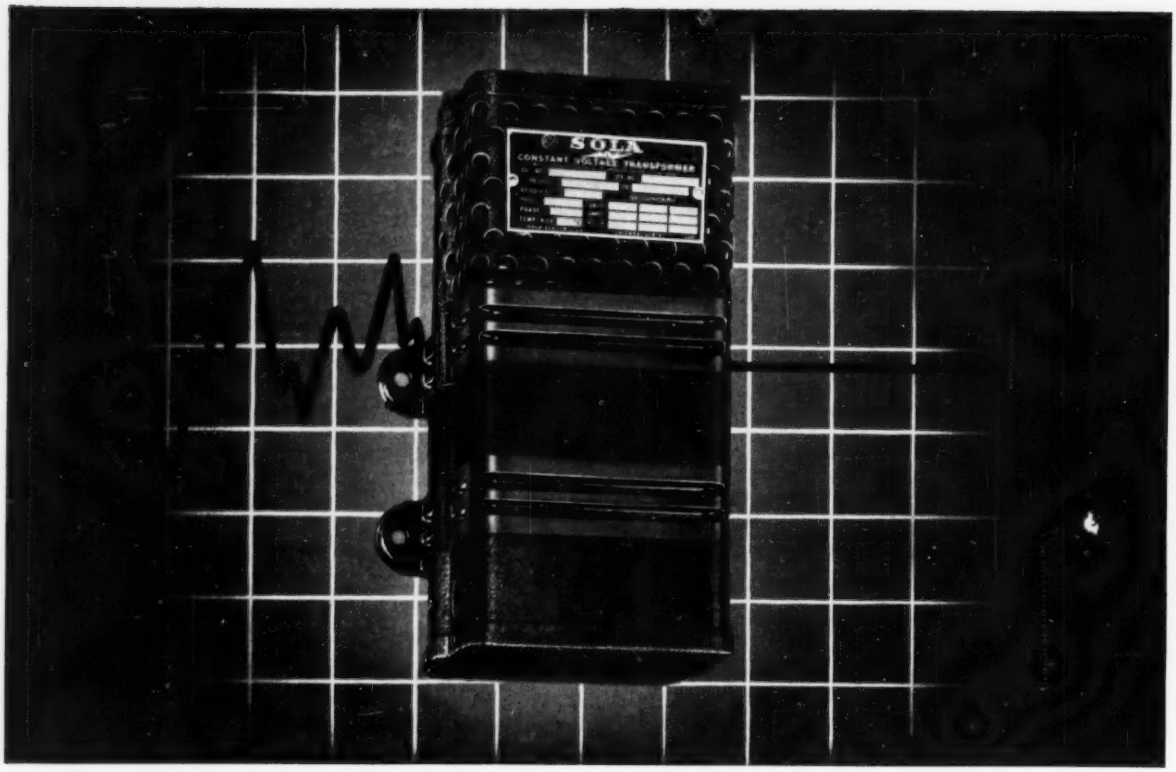
Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____

For more information circle **22** on inquiry card.



Automatic, maintenance-free, instantaneous voltage stabilization

Static-magnetic constant voltage transformers are a practical and efficient solution for controlling input voltage to voltage-sensitive electrical and electronic equipment.

Sola Constant Voltage Transformers are widely used both as built-in components and as accessory units. They differ from regulators which depend solely upon saturation of core materials for their regulating action, or electronic types employing tubes. Sola Constant Voltage Transformers have the following characteristics:

1. Regulation within $\pm 1\%$, with primary voltage (transient or continuous) variations as great as 30%.
2. Response time less than $1\frac{1}{2}$ cycles.
3. No moving or wearing mechanical parts, nor vacuum tubes; requires no manual adjustments.
4. Completely automatic, continuous regulation.
5. Self-protecting against short-circuits on output.
6. Current-limiting characteristics protects load equipment.
7. Can often be substituted in place of conventional non-regulating transformers.
8. Generally smaller than other types of regulators for similar duty.
9. Isolates the input and output circuits.

Forty-three Sola stock units are available in a wide variety of ratings, voltages and types. In addition, custom-designed units can be manufactured (in production quantities) to meet specific requirements.

The experience of the world's largest manufacturer of constant voltage transformers is available to you. We invite you to discuss your voltage stabilizing problems with a Sola Sales Engineer.

SOLA *Constant Voltage* **TRANSFORMERS**

WRITE FOR LITERATURE. Sola Constant Voltage Transformers are completely described in a 24 page manual. Write for a copy of G-CV-142 on your letterhead, please.

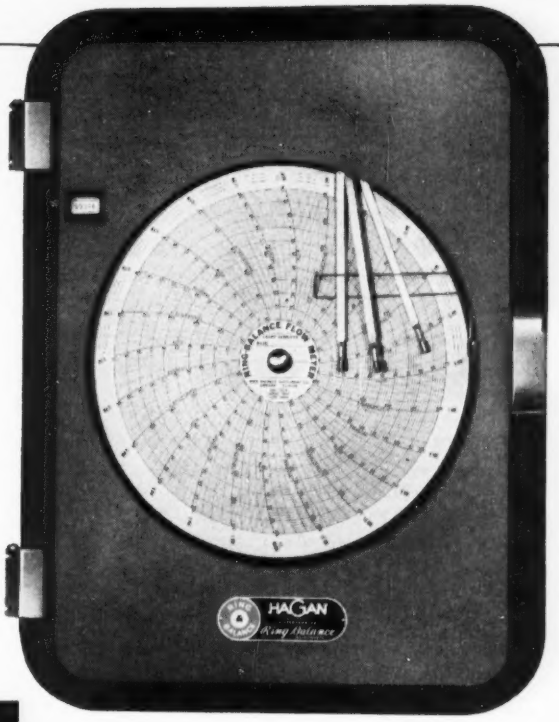
Transformers for: Constant Voltage • Fluorescent Lighting • Cold Cathode Lighting • Mercury Vapor Lighting • Luminous Tube Signs
SOLA ELECTRIC CO., 4633 W. 16th Street, Chicago 50, Illinois, Bishop 2-1414 • *NEW YORK 35:* 103 E. 125th St., TRafalgar 6-6464
PHILADELPHIA: Commercial Trust Bldg., Rittenhouse 6-4988 • *BOSTON:* 272 Centre St., Newton 58, Mass., Bigelow 4-3354
CLEVELAND 15: 1836 Euclid Ave., PRospect 1-6400 • *KANSAS CITY 2, MO.:* 406 W. 34th St., Jefferson 4382 • *Reps. in Other Principal Cities*

For more information circle **23** on inquiry card.

HAGAN Compensated Ring Balance Meters

provide *accurate, automatic* compensation

- for *temperature*
- for *pressure* or
- for *pressure and temperature*



When you measure flow of liquids or gases, and pressure and temperature variations occur, there are two ways to correct meter readings — one by expensive and laborious clerical calculations, the other, by using the Hagan Compensated Ring Balance Meter in the first place. This Hagan Compensated Meter corrects *automatically* for variations in pressure, temperature, or pressure and temperature, and makes a chart record of both the corrected and the uncorrected flow. The built-in integrator totalizes the corrected flow automatically.

Dependable Hagan Ring Balance Meters are simple, ruggedly built, and designed for years of trouble-free service. Some features of Hagan Ring Balance Meters include:

- **Mercury level not critical**
- **Ease of dead-weight calibration**
- **No stuffing boxes or pressure-tight bearings**
- **High sensitivity at low flow rates**
- **Adjustable, full-scale range**

Whatever your metering problems, our engineers are at your service. For full information, phone, wire, or clip the coupon.

HAGAN CORPORATION

RING BALANCE FLOW AND PRESSURE INSTRUMENTS
THRUSTORQ FORCE MEASURING DEVICES
BOILER COMBUSTION CONTROL SYSTEMS
METALLURGICAL FURNACE CONTROL SYSTEMS

Hagan Corporation
Hagan Building
Pittsburgh 30, Pennsylvania

Please send me further information on Hagan Ring Balance Meters. I am particularly interested in _____

NAME _____

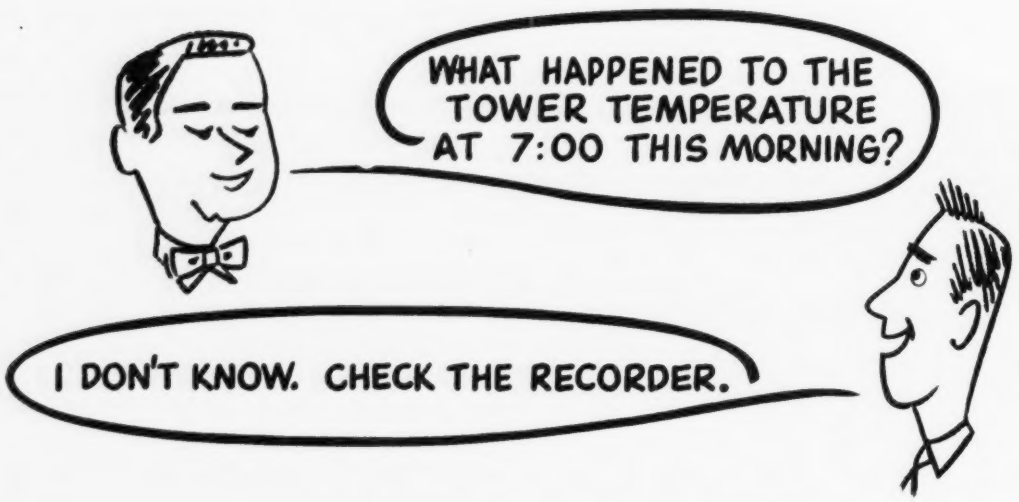
POSITION _____

COMPANY _____

STREET AND NUMBER _____

CITY _____ ZONE _____ STATE _____

For more information circle **24** on inquiry card.



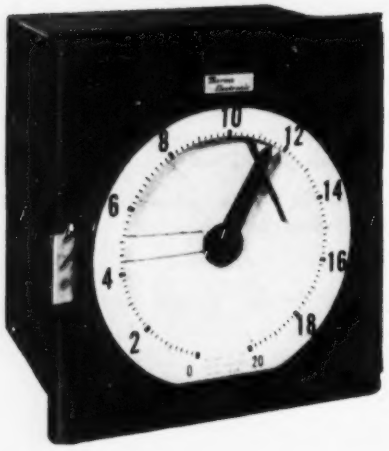
WHAT MAKES A RECORDER GOOD?

Many things. For instance, in the new Thermo Electronic indicating-recorder overall design is simple. The recording system only has three moving parts.

That's one thing. Here's another: the pen arm is driven from a cam. This permits linear charts to be used for almost all measurements, despite the non-linearity of the sensitive element characteristics. When warped or expanded scales are desired, special cams can be supplied.

Furthermore, nylon drive gears are used to provide long life and quiet operation.

There are many other things. If you want to hear about them, let us know. We'll be glad to supply the information. Ask for Catalog No. 60 F.



Indicating recorders are just part of the T-E story. Other T-E products for temperature measurements include controllers, thermocouples, extension wires, plugs and jacks, connector panels, and accessories. Write for details.

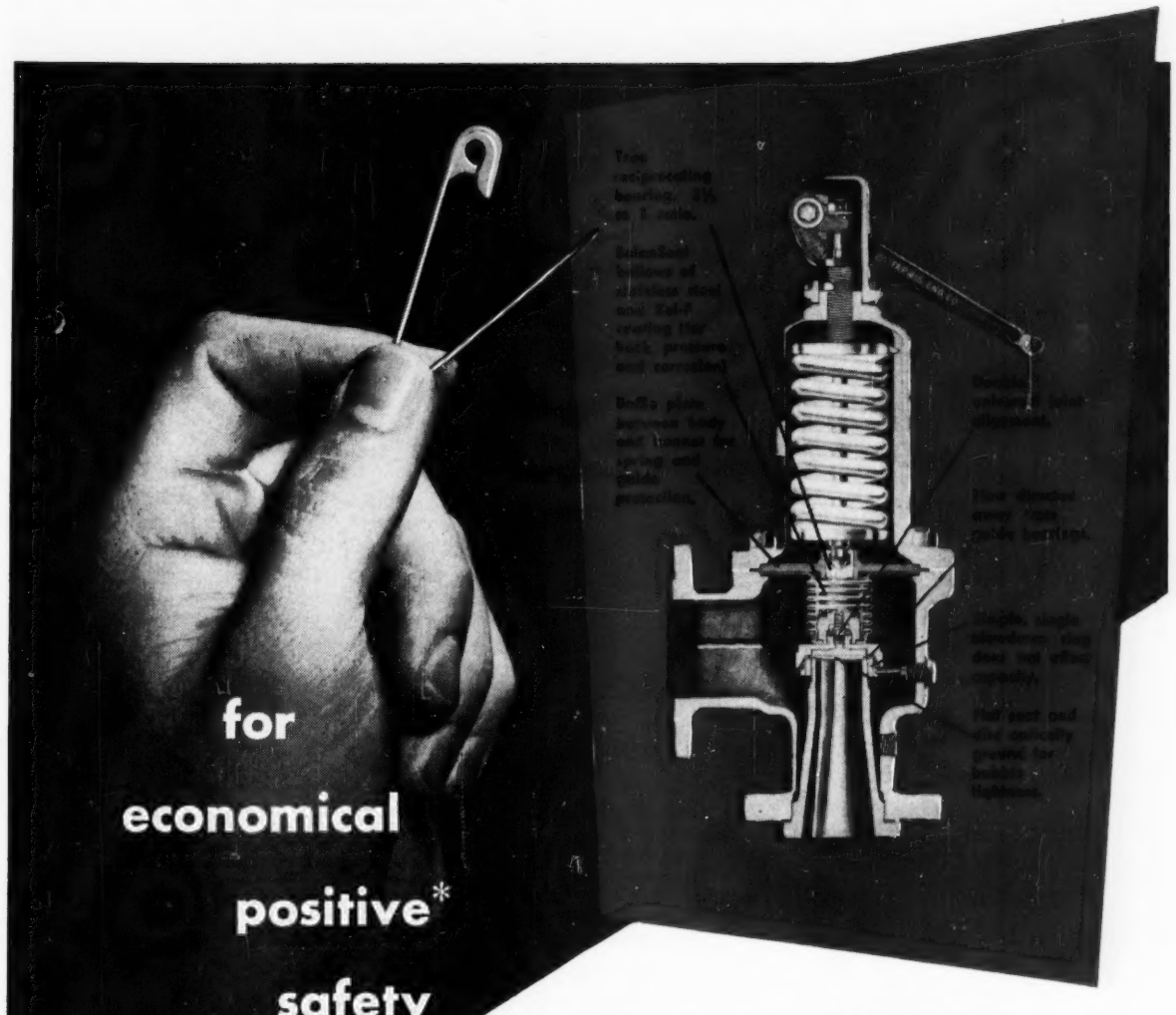
Even if everything goes the way it should with any process where temperature is involved, sometimes it's important to *prove* everything went right. On the other hand, if something is wrong, if standards aren't met, then it's very important to *know* what went wrong in order to correct it. Was it temperature? Or some other process variable?

When an accurate temperature recorder is on hand, a quick check of the record will tell you if temperature was too high, or low, and for how long. If the temperature was off, your problem is pinpointed and you can work on it right away. If it wasn't, you can go on to other variables and find the troublemaker. Either way, a good recorder is a time-saver.

Thermo Electric makes a good recorder —it is accurate (±¼ of 1% of the range), sensitive (better than ±1/20 of 1%), durable, and can be used to record variations in temperature, humidity, solution conductivity, speed, pH, direct current, DC voltage, strain, or other variables. Both potentiometer pyrometer and resistance thermometer bridge types are available, depending on the application.

Thermo Electric Co., Inc.
FAIR LAWN NEW JERSEY

For more information circle **25** on inquiry card.



for economical positive* safety

BalanSeal and FarriSeal Safety-Relief Valves

(Pat'd & Pat. Pending)

Farris

ENGINEERING CORPORATION

610 Commercial Avenue

PALISADES PARK, NEW JERSEY

Corrosion and varying back pressure—the two dangerous enemies of positive safety-relief valve operation—are stopped cold by the ingenious construction of Farris valves. Critical working parts are isolated from the lading fluid so that they can't stick, plug or corrode and the special bellows construction nullifies the effect of back-pressure surge. You get positive protection, under all operating conditions. Manufacturing economies offer realistic pricing—and the design permits the use of much smaller discharge piping, at an important saving. So for safety and economy, specify FarriSeal or BalanSeal safety-relief valves. You're never stuck, because they never stick!

Technical manual, 51B, a treatment on Back Pressure Piping and Surge characteristics and 76-page catalog is yours for the asking.

*ASME-N.B. APPROVED
(Certified for Capacity)

Affiliates:

● FARRIS FLEXIBLE VALVE CORPORATION ● FARRIS STACON CORPORATION ● FARRIS HYDROTORQUE CORPORATION ● FARRIS HYDROSEAL CORPORATION ● FARRIS PICKERING GOVERNOR CO.

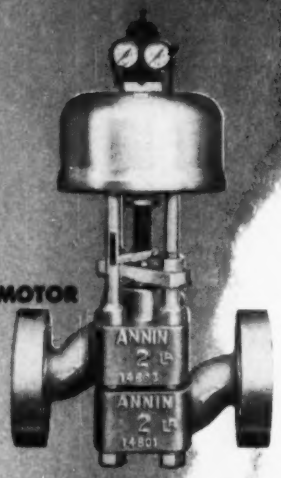
For more information circle **26** on inquiry card.

REACHING FOR NEW HIGHS

Annin's Guided Missile Achievements Help Solve YOUR Extreme Pressure Control Problems

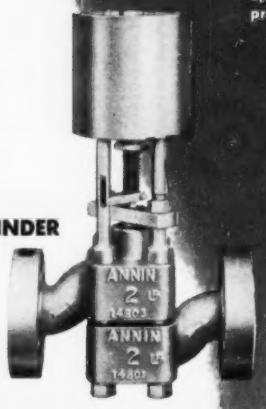
Annin's superiority comes from the rugged proving grounds of guided missile work, where simple valve design, rugged construction and dependable operation are the factors that count. From this beginning Annin research and engineering have constantly reached for "new highs" in efficient control of difficult fluids under extreme conditions of pressure and temperature. This experience can now be applied in solving YOUR high pressure problems with these new standard model Annin Domotor, Cylinder and Handwheel operated valves. Pressure and temperature ratings of 6000 psi (standard*) and −325° F to 1200° F. Like all Annin models they offer flexibility in operation, bubble-tight shut-off, reduction in valve inventory and low maintenance cost. Get the facts today on ANNIN's work in the high pressure field, and what this experience can mean to you in savings and service.

*Special valves now in production to 30,000 psi



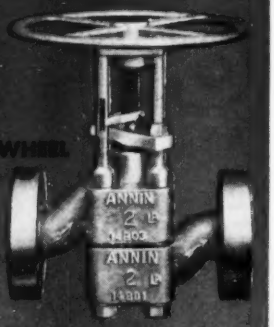
DOMOTOR

Model 2560, series 90-150, pressures to 3600 psi; temperatures −325° F to 1200° F.
Model 3560, series 250, to 6000 psi.



CYLINDER

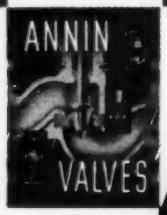
Model 2520, series 90-150, pressures to 3600 psi; temperatures −325° F to 1200° F.
Model 3560, series 250 to 6000 psi.



HANDWHEEL

Model 25, series 90-150, pressures to 3600 psi; temperatures from −325° F to 1200° F.
Model 35, series 250, to 6000 psi.

WRITE TODAY
for illustrated Bulletin showing how and why Annin offers the best buy in control valves.

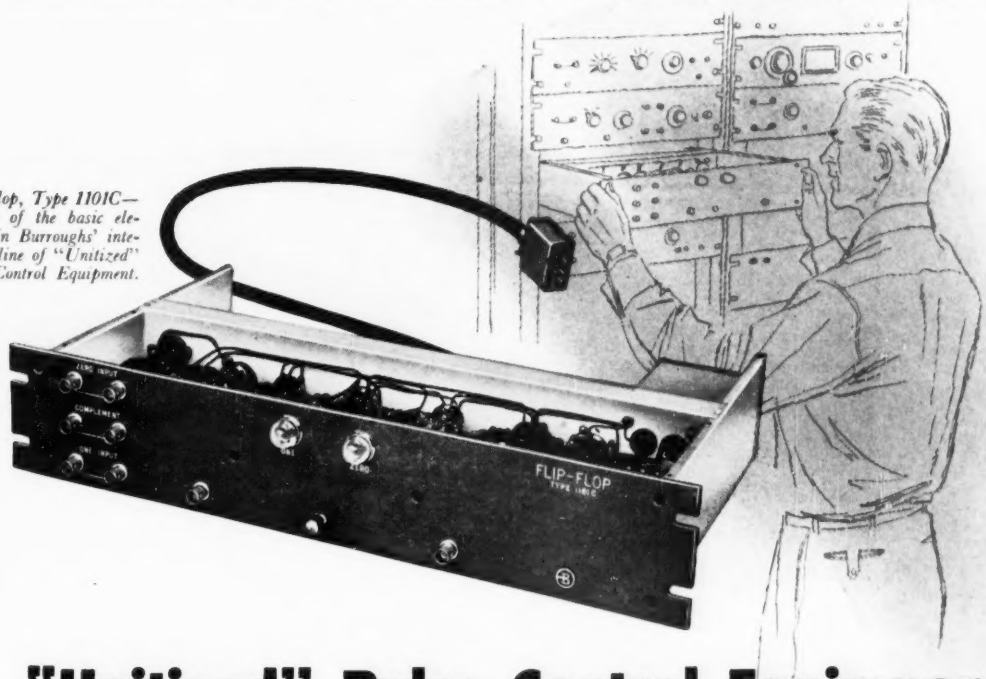


THE ANNIN COMPANY
3500 UNION AVENUE, LOS ANGELES 23, CALIFORNIA

ANNIN *Control* VALVES

For more information circle **27** on inquiry card.

FOR APPLICATIONS IN RADAR, TELEMETERING, DIGITAL COMPUTING, TELEVISION, NUCLEAR PHYSICS



Flip-Flop, Type 1101C—another of the basic elements in Burroughs' integrated line of "Unitized" Pulse Control Equipment.

"Unitized" Pulse Control Equipment

saves time and money in electronic engineering

There's no longer any need to tie up engineering personnel with the time-consuming work of developing and "breadboarding" electronic test circuits. Burroughs, a leader in the office machine industry, now offers an integrated line of "Unitized" Pulse Control equipment covering all the basic functions in pulse circuit engineering. These one-basic-function units are designed with a maximum of flexibility to be used as building blocks for test systems ranging from the very simple to the most complex. Engineers need only make a block diagram of the apparatus needed, assemble the necessary Burroughs units in the plug-in rack, and interconnect them with the various standard coaxial cables and accessories. It's really that easy! It's equally easy to reassemble your units for a different project when your present tests are completed.

YOU SIMPLY "PLUG IN" BURROUGHS FLIP-FLOPS

Burroughs Flip-Flop, Type 1101C, demonstrates the one-basic-function principle that makes Burroughs "Unitized" Equipment so suitable for your needs.

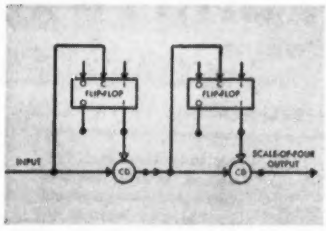
This flip-flop is a bistable circuit designed specifically to provide an output gating voltage to be used in coincidence circuits. The unit contains a pentode Eccles-Jordan circuit capable of being switched at rates up to 2.5 megacycles per second, with 0.1 microsecond pulses.

There are three inputs—Zero, One and Complement—operating from pulse amplitudes of 12 volts or more. Coaxial output jacks marked "Zero Gate" and "One Gate" supply either 0 volts or -23 volts at an impedence level of approximately 680 ohms.

Two neon lights on the front of the panel indicate the position of the flip-flop. A terminal block on the rear of the unit can be used to operate indicator lights installed at a remote point for visual monitoring.

Proved by more than two years of constant use, Burroughs "Unitized" Pulse Control equipment has been purchased by many leading electronic research organizations. Some of the users are: Massachusetts Institute of Technology, University of Michigan, Stanford Research Institute and National Union Radio Corporation.

Scale-of-Four Binary Counter Using Burroughs "Unitized" Equipment



The left flip-flop, Type 1101C, changes state with each input pulse, so that the left coincidence detector (CD) or gate, Type 1201B, is alternately opened and closed with succeeding input pulses, with the result that every other input pulse passes through the left coincidence detector, giving a count of 2. A similar flip-flop and gate combination cascaded to the first combination gives a total scale of 2 x 2 = 4. The number of flip-flop and coincidence detector combinations that can be cascaded is unlimited.

For full information on Burroughs "Unitized" Pulse Control Equipment, write or call Department 15E, Electronic Instruments Division, Burroughs Corporation, 511 N. Broad St., Philadelphia 23, Pa.

PULSE GENERATORS
COINCIDENCE DETECTORS
PULSE DELAYS
FLIP-FLOPS
PULSE GATERS
CHANNEL SELECTORS
MIXERS

ELECTRONIC INSTRUMENTS DIVISION

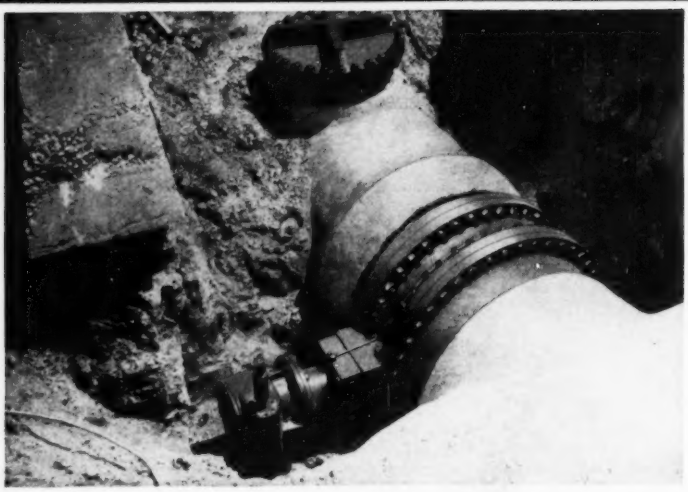
Burroughs

THE BEST KNOWN NAME IN OFFICE MACHINES

For more information circle **28** on inquiry card.

R-S valvEvents

• EXCERPTS FROM THE R-S BOOK OF EXPERIENCE •



Simplified Control and Shut-off of Volume and Pressure

The underground application shows a 50-pound R-S Valve with gear reducer, lubricating lines and operating nut which is hand operated with a wrench. Only a few turns of the wrench are required to open or close the valve.

Practically every R-S Valve installation, particularly when automatically controlled, provides useful experience that can be applied in other industries although they may be far apart in classification. It is this accumulation of engineering experience coupled with unexcelled production facilities that can be so helpful to you.

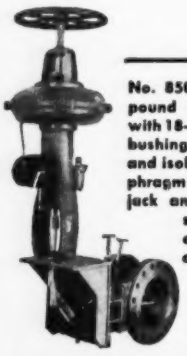
Call the R-S representative at the inception of your application. Benefit by his research and engineering experience in the simplified control and shut-off of volume and pressure.

S. MORGAN SMITH Company • YORK, PA.

MANUFACTURERS OF

HYDRAULIC TURBINES - VALVES

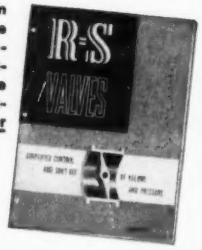
REPRESENTATIVES IN PRINCIPAL CITIES



No. 850—Ten-inch, 300-pound valve equipped with 18-8 shafts, hastelloy bushings, stick lubricators and isolating valves, diaphragm top with headjack and positioner. Installed for the flow control of sour crude petroleum.

No. 801—Three-inch, 125-pound bronze screwed end valve with handlever control and locking device. There is a size and type of R-S Valve for any industry or process.

Catalog No. 20 describes R-S Valves in detail—types, prime movers, applications and specifications. Contains more than 150 illustrations. Write for your copy.



For more information circle 29 on inquiry card.

Circle 30 on inquiry card. →

Handles 4 separate signals

Wider application of miniature instrumentation to your own needs is now possible with the new Fischer & Porter Ratographic miniature recorder. Fitting a panel area only six inches square, the instrument *records* two variables and *indicates* two variables—OR—*records* three variables and *indicates* a fourth. It combines the same dependability, stability and accuracy which characterize *all* Fischer & Porter instruments, large and small. Check the many advantages of this instrument as listed here, then write for further information. Fischer & Porter is always ready to supply engineering assistance on *your complete process instrumentation.*

for recording . . .

- four simple and dependable capsule receivers
- 4" *rectilinear* chart, air or electric drive
- outside dimension 6" square
- convenient daily chart tears off without chart waste

for controlling . . . with F&P point of measurement controller mounted as illustrated, unit offers:

- record of both uncontrolled and controlled variables, with indication of valve and set point signals.
- large, easy to adjust external transfer valve and set point knobs

Glass door: no warping, scratching, or crazing. Recording, indicating and controlling functions continue to operate when chassis is extended from front of panel.

complete process instrumentation

FISCHER & PORTER CO.

1416 County Line Road, Hatboro, Penn.

Company owned sales and service branches strategically located throughout the world.

*T.M., F&P Co.

2282

TYPE 304-AR CATHODE-RAY OSCILLOGRAPH

Just as you will find the Du Mont Type 304-A Cathode-ray Voltmeter of the highest excellence for general-purpose bench testing, you will also find its electrical equivalent, the Du Mont Type 304-AR, an indispensable part of your rack-mounted equipment. The Type 304-AR occupies only 8¾" of height in a standard relay track.

Like the Type 304-A, the Type 304-AR

. . . Has a push-button to calibrate screen in volts.

. . . Has a specially calibrated, illuminated scale.

. . . Incorporates a flat-faced tight-tolerance cathode-ray tube to increase accuracy of measurement.

. . . Reads from 0.1 volts full scale (four inches) to 1000 volts full scale.

. . . Has a frequency response which is flat to d.c. and extends to 300 KC (50% down).

SPECIFICATIONS:

CATHODE-RAY TUBE — New tight-tolerance Type 5ADP-.

VERTICAL DEFLECTION — Deflection factor: 0.1 p-p volt full scale (0.025 p-p or 0.01 rms volt/inch).

Sinusoidal Frequency Response: With direct coupling, flat from zero to not more than 10% down at 100,000 cps; With capacitive coupling, down not more than 10% at 10 and 100,000 cps; Direct and capacitive coupling, down not more than 50% at 300,000 cps.

Undistorted Deflection: More than 4 inches; Expansion, equivalent of 20 inches (no on-screen distortion).

AMPLITUDE MEASUREMENT — Range: Volts Full Scale, 0 to 0.1, 1, 10, 100 volts; continuously variable control to multiply range from 1 to 10; Calibrated Scale reads directly in volts. Overall Accuracy, 5%.

HORIZONTAL DEFLECTION — Deflection Factor: 0.3 p-p (0.1 rms) volts/inch.

Sinusoidal Frequency Response: Direct coupling, flat from zero to not more than 10% down at 100,000 cps. Capacitive coupling down not more than 10% at 10 and 100,000 cps; Direct and capacitive coupling, down not more than 50% at 300,000 cps. Undistorted Deflection: more than 4 inches.

LINEAR SWEEPS — Frequency range: Recurrent and driven, 2 to 30,000 cps. Extra-low-frequency sweeps available by attaching capacitance; 0.5 second of sweep/mfd. Sweep expansion equivalent of 30 inches.

OVERALL DIMENSIONS — Height, 8¾"; width, 19"; depth, 19½". Weight, 50 lbs.

PRICE $400*

***ATTENTION MANUFACTURERS!** For incorporating the Type 304-AR into your equipment, contact us about special finishes to match your product.

DU MONT *for Oscillography*

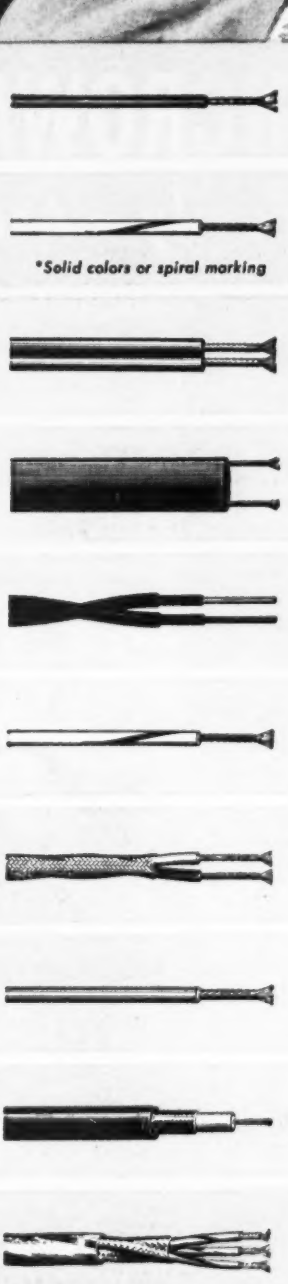
INSTRUMENT DIVISION • ALLEN B. DU MONT LABORATORIES, INC. • 760 BLOOMFIELD AVENUE, CLIFTON, N. J.

For more information circle **31** on inquiry card.

We haven't cut corners on QUALITY CONTROL to speed deliveries for—

CHESTER plasticord-plasticote WIRES & CABLES

Extra shifts, not speed-ups are the way Chester catches up on production to meet your delivery dates. Chester Wires and Cables are never rushed through... every foot is quality controlled according to the highest standards known to the industry. This is the reason Chester Wires and Cables are of uniform quality, always dependable, whether you use a foot or a spool. For an extra measure of reliability, specify Chester, for your next electrical or electronic requirements.



*Solid colors or spiral marking

- JAN-C-76 WIRES* SRIR, SRHV, SRRF, WL
- 105°C, 90°C, 80°C UL APPROVED; 120°C*
- FLEXIBLE CORD
- TV LEAD-IN WIRES
- COMMUNICATION WIRES & CABLES TO SPECIFICATIONS
- LACQUERED AND NYLON WIRES
- SHIELDED WIRES & CABLES
- INSTRUMENT WIRES
- COAXIAL CABLE
- SPECIAL WIRES & CABLES TO SPECIFICATIONS

WIRE AND CABLE DATA SHEETS
Contains complete information on Chester Quality Conductors. Call or write for yours, today!

"Chesty" INVITES INQUIRIES concerning custom constructions including polyethylene, polyvinyl chloride, nylon, braided and lacquered wires, special insulating materials, glass, yarn or any known material. Recommendations will be made without obligation.

CHESTER CABLE CORP.
CHESTER • NEW YORK

REGISTERED U.S. PAT. OFF.

For more information circle 32 on inquiry card.

Now

PRECISION ENGINEERING
CUSTOM MANUFACTURING

TEST MICROWAVE CRYSTALS

Easily – Accurately

FACTS

- Accuracy

Relative Noise Figure:	1.0 db max. error 0.3 db mean error
Relative Sensitivity:	2.0 db max. error 0.6 db mean error
Pair Matching:	Sufficient to assure 20-db suppression of local oscillator noise
Conversion Loss:	0.9 db max. error 0.3 db mean error
Noise Temperature:	0.7 max. error 0.3 mean error

- Accepts ceramic cartridge and coaxial types of both normal and reversed polarities.
- Remote test jack permits testing crystals without removing them from receiver.
- Portable
- Self-contained

PRICE $97.00

MEASURES

- Relative Noise Figure
- Relative Sensitivity
- Match of Crystal Pairs
- Conversion Loss
- Noise Temperature

APPLICATIONS

- As field test set to determine receiver sensitivity, as determined by crystal quality.
- As laboratory test set to choose representative and extreme crystals from a group.
- As incoming inspection test set to cull crystals that arrive in damaged condition.

Airborne Instruments Laboratory

INCORPORATED

160 OLD COUNTRY ROAD MINEOLA, N.Y.

Betrayed by water temperature

. . . at 20 Fathoms

The ocean is in reality a number of layers or currents of water "separated" by differences in temperature. The temperature at various levels is determined by lowering a small measuring instrument, called a Bathythermograph, into the water.

The Bathythermograph provides invaluable information for our armed forces in plotting "pictures" of the directions and levels of these ocean currents.

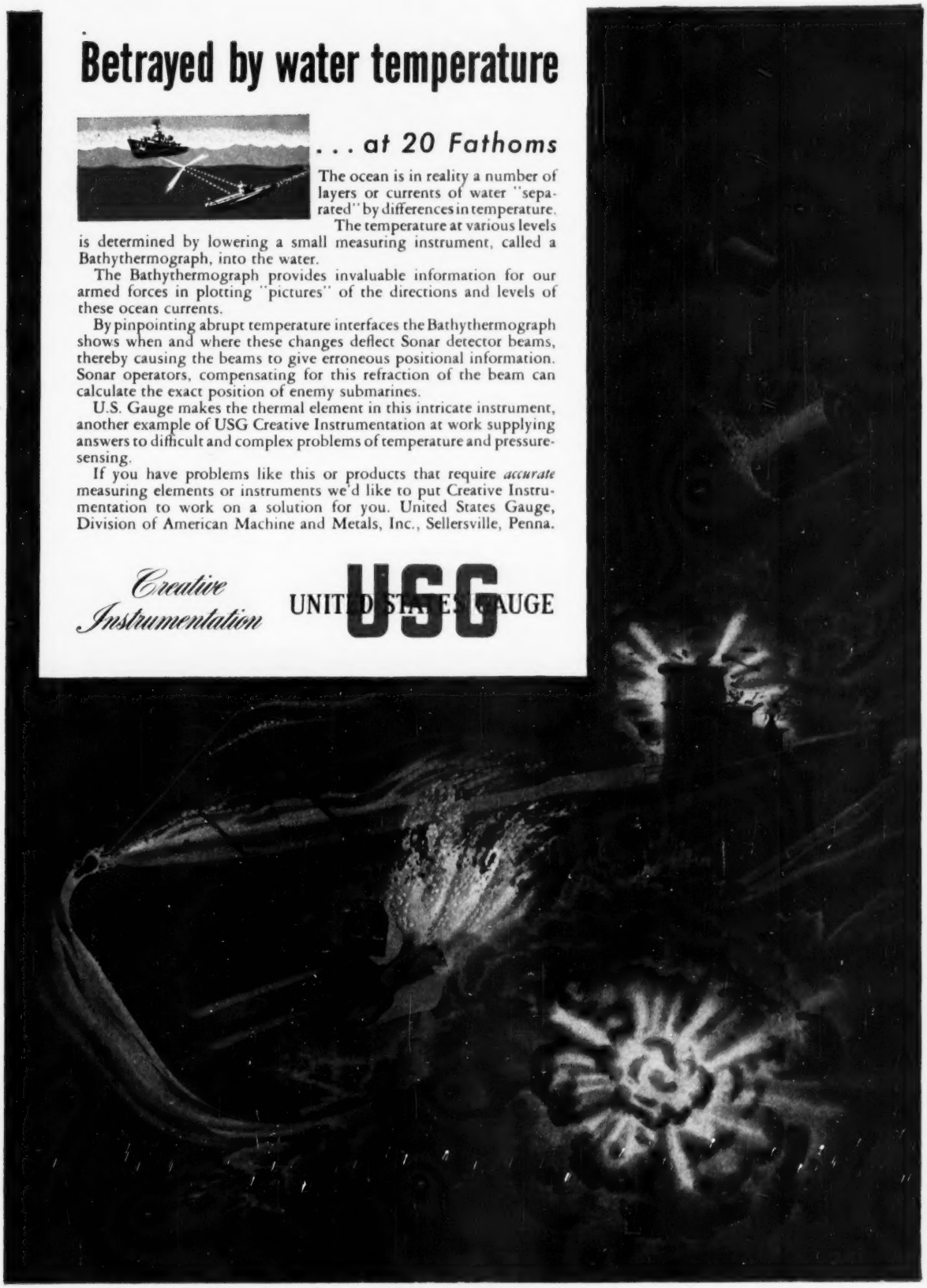
By pinpointing abrupt temperature interfaces the Bathythermograph shows when and where these changes deflect Sonar detector beams, thereby causing the beams to give erroneous positional information. Sonar operators, compensating for this refraction of the beam can calculate the exact position of enemy submarines.

U.S. Gauge makes the thermal element in this intricate instrument, another example of USG Creative Instrumentation at work supplying answers to difficult and complex problems of temperature and pressure-sensing.

If you have problems like this or products that require *accurate* measuring elements or instruments we'd like to put Creative Instrumentation to work on a solution for you. United States Gauge, Division of American Machine and Metals, Inc., Sellersville, Penna.

Creative Instrumentation

UNITED STATES GAUGE **USG**



PRODUCTS OF UNITED STATES GAUGE . . . Absolute Pressure Gauges • Aircraft Instruments • Air Volume Controls • Altitude Gauges • Boiler Gauges • Chemical Gauges • Mercury Gas and Vapor Dial Thermometers • Glass Tube and Industrial Thermometers • Flow Meters • Inspectors' Test Gauges • Precision Laboratory Test Gauges • Marine, Ship and Air-Brake Gauges • Voltmeters • Ammeters • Welding Gauges

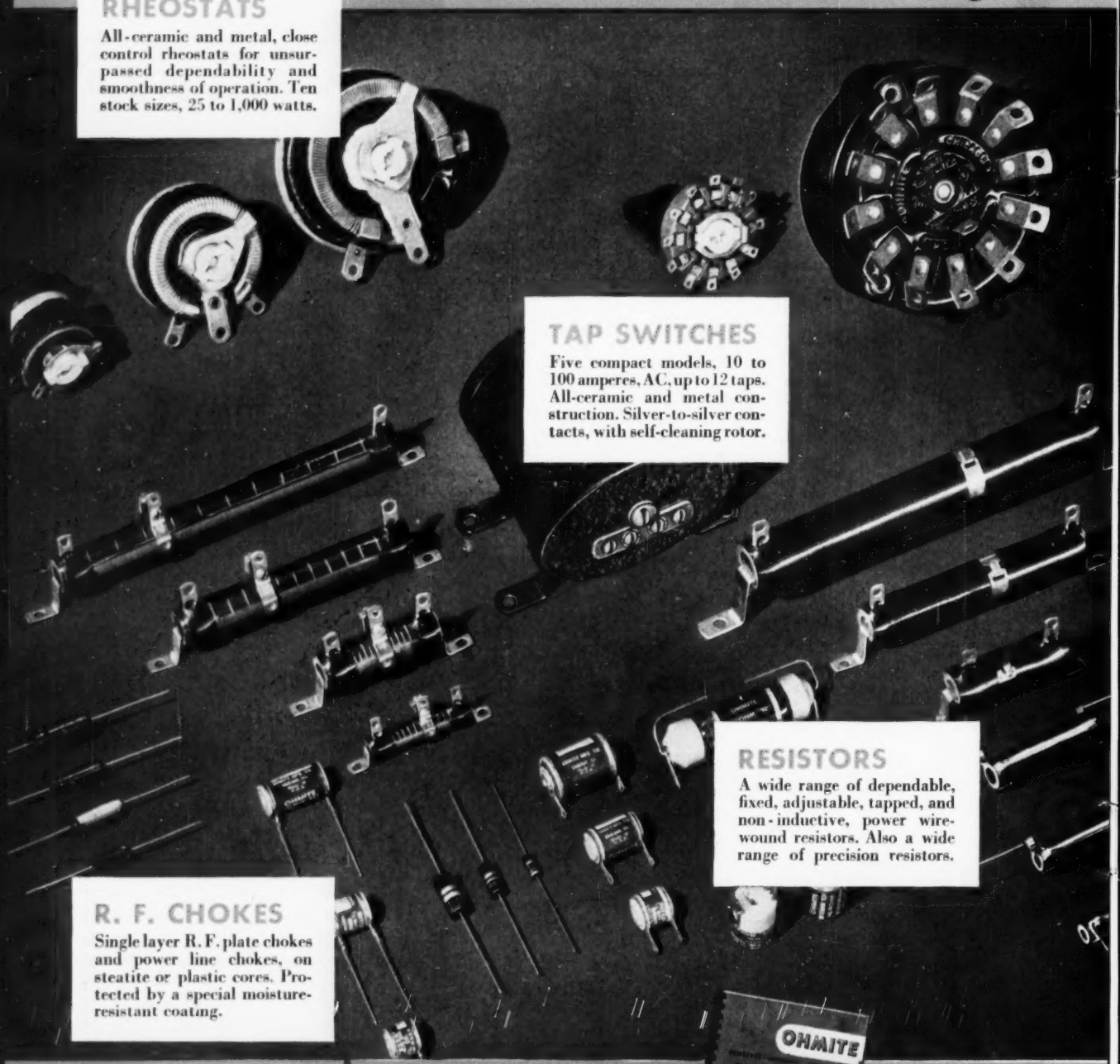
OTHER DIVISIONS OF AMERICAN MACHINE AND METALS, INC. AT SELLERSVILLE, PA.: GOTHAM INSTRUMENTS, AND AUTOBAR SYSTEMS

←——Circle **33** on inquiry card.

For more information circle **34** on inquiry card.

OHMITE®

FOR *Dependability*



RHEOSTATS

All-ceramic and metal, close control rheostats for unsurpassed dependability and smoothness of operation. Ten stock sizes, 25 to 1,000 watts.

TAP SWITCHES

Five compact models, 10 to 100 amperes, AC, up to 12 taps. All-ceramic and metal construction. Silver-to-silver contacts, with self-cleaning rotor.

RESISTORS

A wide range of dependable, fixed, adjustable, tapped, and non-inductive, power wirewound resistors. Also a wide range of precision resistors.

R. F. CHOKES

Single layer R. F. plate chokes and power line chokes, on steatite or plastic cores. Protected by a special moisture-resistant coating.

Be Right with **OHMITE**

OHMITE MANUFACTURING COMPANY

3615 HOWARD ST., SKOKIE, ILLINOIS (Suburb of Chicago)

WRITE on company letterhead for Catalog and Engineering Manual No. 40

SYLPHON SAFETY TYPE
TEMPERATURE REGULATOR
No. 926

The temperature regulator that gives you a PLUS*

**Has "Fail Safe" feature—protects against accidental overheating*

● This Sylphon Safety Type Regulator No. 926 not only gives you constant, positive temperature control—but also protects against accidental overheating. The operation is simple and safe. If the connecting tubing or bulb should be accidentally injured, causing loss of the thermostatic charge, the Regulator *fails safe;* the control valve closes automatically. No overheating and consequent damage to products in process. Savings in manpower, manhours and fuel.

And for versatility, No. 926 scores high! It can be furnished with a reverse-acting valve for cooling control; the control valve will *open* if the thermostatic charge should be accidentally lost. Also available with fin type bulb for controlling temperature of air and gases.

Sylphon Safety Type Regulator No. 926 is sturdily built to give years of trouble-free service. Neat and compact. Has many uses. For example, for control of chemical heating tanks, cooling of mixing tank reactions, engine and compressor cooling, heating of water for showers, etc. Ideal as standard equipment. For the complete story about No. 926, write for Bulletin VE-D.

FIRST WITH BELLOWS

Temperature Controls • Bellows Devices • Bellows Assemblies

FULTON SYLPHON
DIVISION

ROBERTSHAW-FULTON CONTROLS CO., KNOXVILLE 1, TENN.

Canadian Representatives, Darling Brothers, Montreal

← Circle **35** on inquiry card.

For more information circle **36** on inquiry card.

Announcing new Parker *"In-tru"* Fittings for easier, foolproof installations

Simply push—then tighten! That's all you have to do to install the new Parker *"In-tru"* tube fittings. These flareless fittings are especially well suited for instrumentation lines of ¼" through ½" outside diameters. Here's what makes them so easy and foolproof to use . . . even by pickup labor on construction jobs:

To connect a Parker *"In-tru"* fitting, you don't have to take the fitting apart. Just do three things. First, cut off the tube squarely. Second, push the tube through the nut and ferrule until it rests on the seat within the fitting body. Then, tighten the nut.

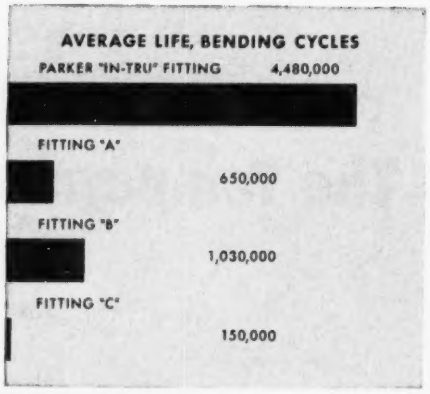
The wedging action of the nut, when tightened, causes the ferrule to "bite" into the outer surface of the tube wall. This turns up a shoulder of metal for a leakproof, vibration-proof connection. The cutting action of the ferrule is not hidden, so the extent of the "bite" is plainly visible if the joint is disconnected to examine the "bite".

Leakproof Parker *"In-tru"* fittings are made of brass. They are also available in aluminum alloy on special order.

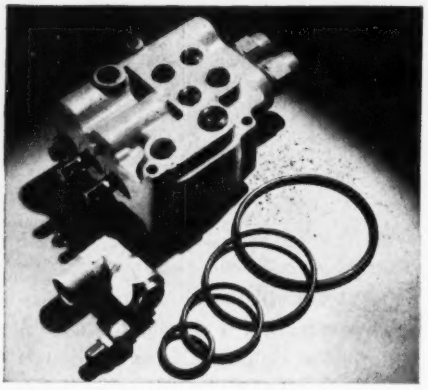
Call your nearest Parker distributor for complete information about shapes, sizes, and prices. Or, write us for Catalog 4320A1.

TUBE AND HOSE FITTINGS DIVISION
The Parker Appliance Company
Section 402Q, 17325 Euclid Avenue, Cleveland 12, Ohio

Parker
Hydraulic and fluid system components



Vibration life tests proved Parker *"In-tru"* fittings averaged four-times longer life than any of the three competitive makes tested.

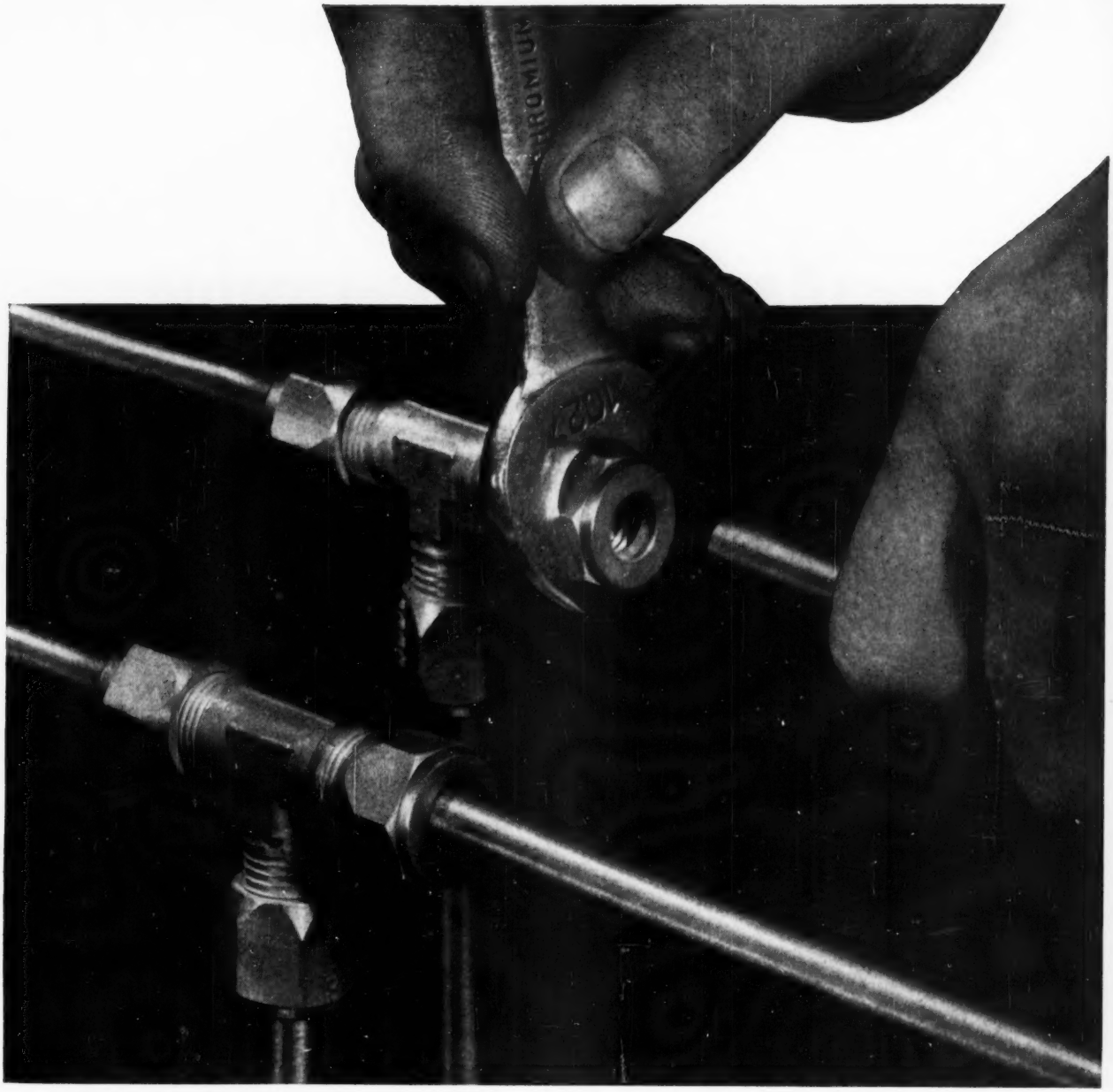


What other Parker products interest you? Triple-lok flare fittings? Hydraulic control valves? O-rings? Write us for information.

CALL YOUR NEAREST DISTRIBUTOR FOR PARKER INDUSTRIAL FITTINGS

Akron 9, Ohio	B. W. Rogers Co. 850 South High St.
Baltimore 13, Md.	Carey Machinery & Supply Co. 3501 Brehms Lane
Baltimore 5, Md.	Whitehead Metal Products Co. 4300 E. Monument St.
Beaumont, Tex.	Standard Brass & Mfg. Co. 705 Milam St.
Birmingham, Ala.	Mill & Textile Supply, Inc. 3128 Third Ave. South
Boston 15, Mass.	A. E. Borden Co., Inc. 176 Brookline Ave.
Bryson City, N. C.	Wallace Co. of N. C. P. O. Box 572
Buffalo 7, N. Y.	Whitehead Metal Products Co. 2128 Elmwood Ave.
Cambridge 39, Mass.	Whitehead Metal Products Co. 281 Albany St.
Cedar Rapids, Ia.	Globe Machinery & Supply Co. 309 8th Ave. S. E.
Charleston, W. Va.	Persingers, Inc. 514 Elizabeth St.
Charlotte 1, N. C.	Industrial Piping Supply Co. 1501 Dowd Rd.
Chicago 14, Ill.	Wallace Tube Co. 1300 Diversey Parkway
Cincinnati 29, Ohio	Williams & Co. 3231 Fredonia Ave.
Cleveland 14, Ohio	B. W. Rogers Co. 1279 East 12th
Cleveland 14, Ohio	Williams & Co. 3700 Perkins Ave.
Columbus 8, Ohio	Williams & Co. 851 Williams Ave.
Dallas 9, Tex.	Metal Goods Corp. 6211 Cedar Springs Rd.
Davenport, Ia.	Globe Machinery & Supply Co. 410 E. Second St.
Dayton 10, Ohio	J. N. Fauver Co. 1534 Keystone Ave.
Denver 2, Colo.	Metal Goods Corp. 2425 Walnut St.
Des Moines 8, Ia.	Globe Machinery & Supply Co. East First & Court Ave.
Detroit 1, Mich.	J. N. Fauver Co. 49 West Hancock St.
Harrison, N. J.	Whitehead Metal Products Co. 1000 South Fourth Ave.
Houston 3, Tex.	Metal Goods Corp. 711 Milby St.
Houston 1, Tex.	Standard Brass & Mfg. Co. 2018 Franklin St.

For more information circle **37** on inquiry card.



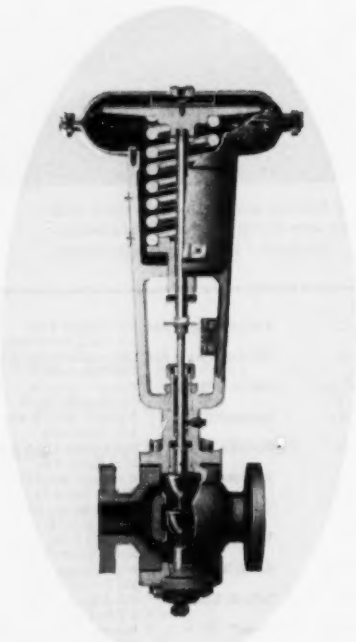
Simply push, then tighten. Anyone can quickly install new Parker "*In-tru*" tube fittings. You don't even have to take them apart before making connections. These flareless fittings are both leakproof and vibration-proof. They are designed for instrumentation lines using ¼" through ½" outside diameters.

Indianapolis, Ind.	Avels Sales & Engineering Co. 16 W. 22nd St.
Jacksonville, Fla.	Florida Metals, Inc. 2937 Strickland St.
Kansas City 16, Mo.	Metal Goods Corp. 1300 Burlington Ave.
Knoxville 5, Tenn.	Leinart Engineering Co. 412 E. 5th Ave.
Los Angeles, Cal.	Haskel Engineering & Supply 721 Broadway, Glendale 4
Los Angeles 12, Cal.	Metropolitan Supply Co. 353 E. 2nd St.
Memphis, Tenn.	J. E. Dilworth Co. 730 South Third St.
Miami, Fla.	Florida Metals, Inc. 4100 N. W. 37th Ct. Hialeah
Milwaukee 3, Wis.	Morman Belting & Supply Co. 522 W. State St.
Milwaukee 4, Wis.	Wallace Companies of Wisconsin, Inc. 838 South 6th St.
Minneapolis 15, Minn.	Vincent Brass & Copper Co. 124 Twelfth Ave. South
New Orleans 12, La.	Metal Goods Corp. 432 Julia St.
Newport News, Va.	Noland Company 27th St. & Virginia Ave.
New York, N. Y.	Nielsen Hydraulic Equipment, Inc. 5 Penn Place, Pelham Manor 65
New York 14, N. Y.	Whitehead Metal Products Co. 303 W. 10th St.
Odessa, Tex.	Snyder Co., Inc. 2604 Kermit Highway
Philadelphia, Pa.	Louis H. Hein Co. 15 W. Lancaster Ave., Ardmore
Philadelphia 40, Pa.	Whitehead Metal Products Co. 1955 Hunting Park Ave.
Pittsburgh 33, Pa.	Williams & Co. 901 Pennsylvania Ave.
Portland 10, Ore.	Hydraulic Power Equipment Co. 2316 N. W. Savier St.
Roanoke 10, Va.	Noland Company 1226 Center Ave. N. W.
Rockford, Ill.	Rockford Tool & Transmission Co. 802 Broadway
Salt Lake City 4, Utah	Pace-Turpin & Co. 726 South Third West
San Francisco 3, Cal.	General Machinery & Supply Co. 1346 Folsom St.
Seattle 9, Wash.	Palmer Supply Co. 222 Westlake North
Shreveport, La.	Standard Brass & Mfg. Co. 1557 Texas Ave.
St. Louis 15, Mo.	Metal Goods Corp. 5239 Brown Ave.
Syracuse 4, N. Y.	Whitehead Metal Products Co. 207 W. Taylor St.
Tampa, Fla.	Florida Metals, Inc. 222 N. 12th St.
Toledo 2, Ohio	Williams & Co. 650 E. Woodruff Ave.
Tulsa, Okla.	Ardun Supply Co. 303 S. Frankfort
Tulsa 3, Okla.	Metal Goods Corp. 302 N. Boston
Export	Mercator Corp. 438 Walnut St., Reading, Pa., U.S.A.

For more information circle **37** on inquiry card.

Meet the modern valve for modern process control

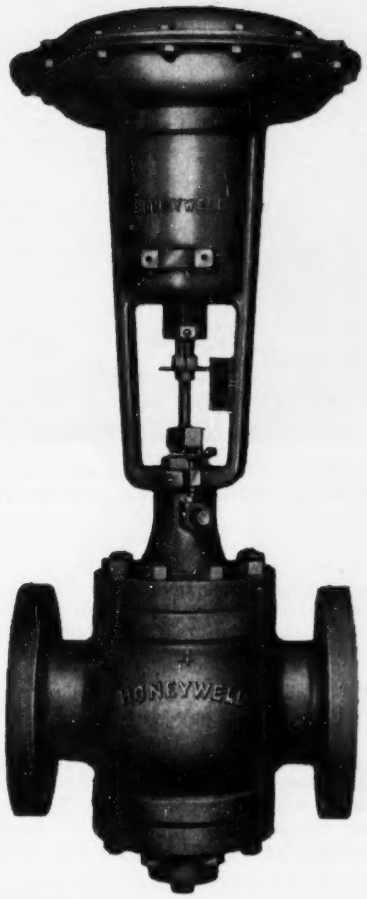
the new Honeywell Series 800



Look at these features:

- **SMALL AIR CHAMBER . . .**
  minimum volume of dead air assures fast response to control air signals.
- **TIGHTLY SEALED DIAPHRAGM . . .**
  extra thick, molded-in gasket around bolt circle prevents air leaks; reinforced construction gives high flexibility, long life.
- **STAY-TIGHT STEM LOCK . . .**
  won't separate under most severe vibration.
- **STURDY, ATTRACTIVE YOKE . . .**
  no useless weight, but plenty of strength; stands roughest handling. Pads on both sides of yoke facilitate mounting of auxiliary equipment.
- **CHOICE OF BONNET DESIGN . . .**
  screwed or bolted.
- **PACKING . . .**
  graphite-impregnated asbestos or shredded Teflon.

For more information circle **38** on inquiry card.



New Solid V-ported Disc for high-velocity service

Now available with the Series 800 double seated line is this solid equal percentage disc. It's especially applicable to high velocities and high pressure drops; has better stability and resistance to erosion; minimizes noise. Rangeability up to 50 to 1.

Here's the new look—coupled with new performance standards—in diaphragm motor valves. The Honeywell Series 800 incorporates every feature of design that is demanded by the process control applications of today . . . and of tomorrow, too.

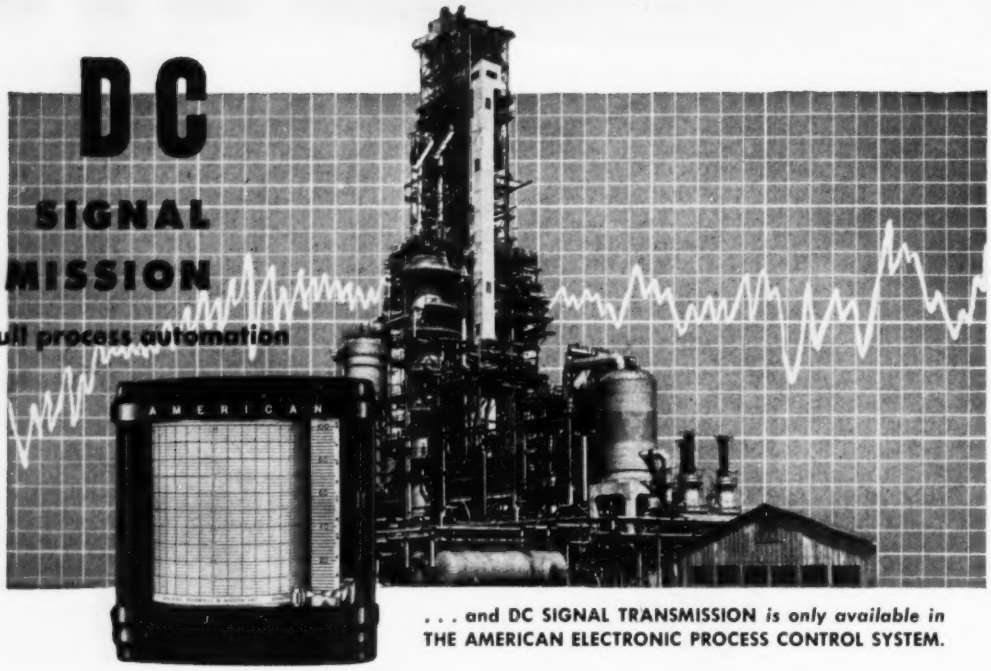
In response . . . sensitivity . . . reproducibility . . . overall performance . . . the Series 800 valve is the ideal partner of advanced instrumentation. It's available in a full range of styles and sizes. Get complete technical data today, by writing for Bulletin 800.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*
1904 Windrim Ave., Philadelphia 44, Pa.

MINNEAPOLIS
Honeywell
VALVE PRODUCTS
First in Controls

DC SIGNAL TRANSMISSION

the key to full process automation



. . . and DC SIGNAL TRANSMISSION *is only available in* THE AMERICAN ELECTRONIC PROCESS CONTROL SYSTEM.

Most modern electronic print-out, monitoring and computing equipment is designed for DC operation. Until recently it was impractical to integrate these automatic devices with instruments that measure process variables. Consequently, complete process automation was impossible.

Now—the new American Electronic Process Control System provides the major compatability factor essential to achieve the economic advantages of full process automation: *DC signal transmission.*

The instantaneous DC transmission of process variable measurements permits higher controller gains that result in a new concept of control performance. At the same time, it makes possible the efficient "electric nerve center" so essential to the low-cost operation of the ultra modern plant of today and the standard plant of the future. In short, the American Electronic Process Control System provides the only practical foundation for integration of . . .

1. **AUTOMATIC LOGGING** — the continual listing of operational data in tabulated digital form.
2. **AUTOMATIC MONITORING** — the centralized supervision of all measured criteria for maximum safety and efficiency.
3. **AUTOMATIC COMPUTING** — for precise accounting and engineering analysis at highest speed and lowest cost. Ushers in the fully automatic plant with completely automatic product analysis and control.

In addition to this unique versatility, the American Electronic Process Control System offers *improved quality of control*—tighter control that opens the way for a reduction in the size of process equipment and consequently a lower capital investment for a given through-put. Furthermore — *simplified communication* — with two-wire DC signal transmission lines that are unaffected by induced alternating currents and varying line resistance, the cost and complexity of present systems will be vastly reduced.

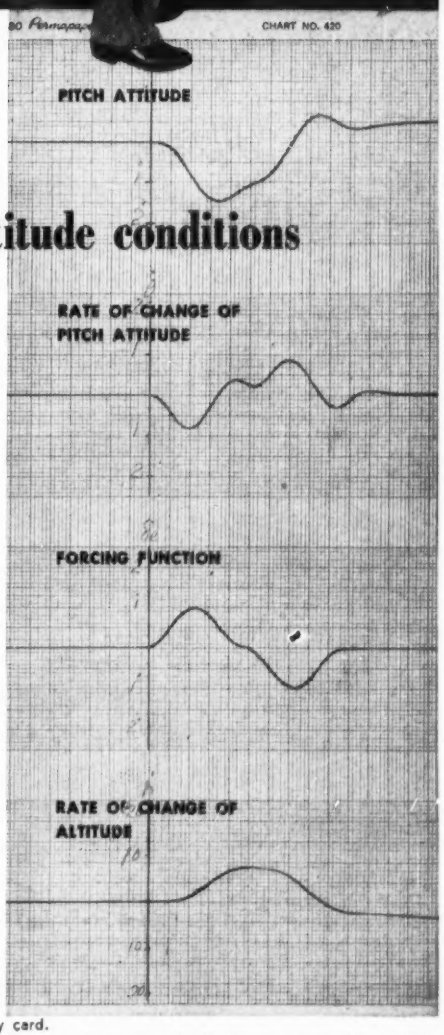
When you select process control equipment, basic considerations are performance, initial installed cost, reliability, maintenance, and flexibility. The advanced design and operation of all instruments in the American Electronic Process Control System assure complete satisfaction on every count. Convince yourself. *Write for Catalog No. 164.*

AMERICAN INDUSTRIAL INSTRUMENTS

A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'HANCOCK' VALVES, 'ASHCROFT' GAUGES, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, AIRCRAFT PRODUCTS. BUILDERS OF "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES.

For more information circle **39** on inquiry card.



Four-channel recording correlates simulated jet bomber airspeed and altitude conditions

At Eclipse-Pioneer, engineers make good use of Sanborn 4-channel recording systems in conjunction with high precision analogue computers to establish performance criteria for automatic flight systems and components.

At other laboratories Sanborn Systems are being used to record such phenomena as: stress, strain, pressure, displacement, thickness, velocity, acceleration, current, voltage, temperature, torque, light, flow, force, load, position, rpm, radiation and tension.

SANBORN OSCILLOGRAPH RECORDING SYSTEMS HAVE MANY APPLICATIONS. They are used in a great many different fields where accurate and permanent graphic registration of almost any electrical phenomena (whose frequency range is zero to 100 cycles per second) is required.

Sanborn Systems are widely used because of the availability and ready interchangeability of amplifiers and preamplifiers, as well as such Sanborn advantages as: inkless recording in true rectangular coordinates, high torque movement, time and code markers and wide choice of paper speeds. In addition, a basic choice of systems, 1-, 2-, and 4-channels, provides a system to fulfill almost any laboratory requirements.

WRITE FOR CATALOG

Sanborn Company
INDUSTRIAL DIVISION
CAMBRIDGE 39, MASSACHUSETTS, U.S.A.

For more information circle **40** on inquiry card.

Oscilloscope records are easily read

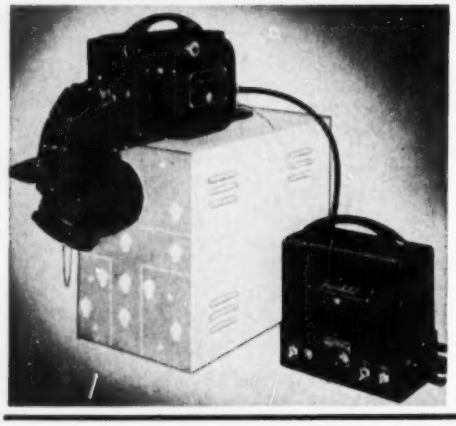
when prints are made with the Fairchild-Polaroid® Oscilloscope Camera

There are three good reasons why oscilloscope traces can be read quickly and easily when they are photographed by Fairchild's adaptation of the Polaroid camera:

1. The trace reads normally—left to right—instead of reverse.
2. Reduction is exactly half life-size for easy measurement of values, especially when a grid is used.
3. Each print records two images, especially handy for before-and-after work.

Operation is as easy as 1-2-3. In two minutes or less you can set up the camera, snap the shutter, and pull the tab. Then you wait one minute more and remove the finished print. No focusing and no special training are required.

Important note—Delivery of Fairchild-Polaroid Oscilloscope Cameras can be had in just a few weeks. Write today for prices and information.



For still or continuous-motion recording on 35-mm film or paper Use the FAIRCHILD OSCILLO-RECORD CAMERA

Speed is continuously variable through an exclusive electronic control. Film is sprocket-driven so there is no slippage. There are no belts or pulleys. Top-of-scope mounting eliminates need for tripod and keeps scope controls easily accessible. Provision for three film lengths—100, 400, or 1,000 feet. Delivery in about four months.

● **Full information about the Fairchild-Polaroid and Oscillo-Record Cameras awaits your request. Write today to *Fairchild Camera and Instrument Corporation, Robbins Lane, Syosset, Long Island, New York, Department* 120-19 F2.**

FAIRCHILD
OSCILLOSCOPE RECORDING CAMERAS

For more information circle 41 on inquiry card.

NOT EVEN DRY CEMENT CAN PLUG THIS FLEX VALVE!

At Porete Manufacturing Co., North Arlington, N. J., where precast concrete roofing slabs are made, production depends on a constant supply of dry cement, unloaded through a pipe line under pressure. Using a rotary plug valve, it took 3 men an 8-hour day to handle 70 tons. Frequently the valve jammed after only half an hour of operation, making it necessary to force the action with a bar. Often, in cold weather, the valve had to be heated. Then Porete discovered Flex Valve. For more than two years the Flex Valve shown here has given trouble-free service. One man now controls the diaphragm-operated mechanism with a simple lever. If you have a problem in controlling the flow of any hard-to-handle fluid, send for Catalog No. FL 382C.

Exclusive FLEX VALVE Features

(Pat'd & Pat. Pending)

• Will outwear any metal valve on abrasive service. Proven minimum 11 to 1 life over metal • Full pipe capacity • will not freeze up in outdoor service • Excellent control characteristics in first 1/3 of travel • Complete closure for bubble-air tightness • Tight on grits up to 1/8" • No obstructions, pockets, or internal parts • Valve body available in pure gum rubber, neoprene, butyl, buna-n, buna-s, food stock and special compounds.

YOUR MONEY BACK IF IT PLUGS

Representatives in Principal Cities

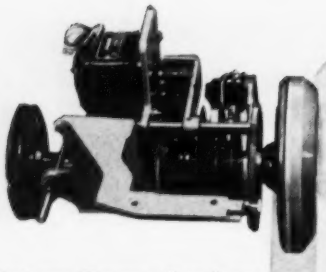
Farris

FLEXIBLE VALVE CORP.

Palisades Park, N. J., U. S. A.

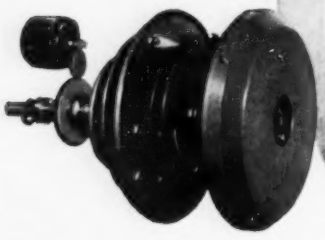
affiliates: FARRIS ENGINEERING CORP. • FARRIS STACON CORP. • FARRIS HYDROSEAL CORP. • FARRIS HYDROTORQUE CORP. • FARRIS PICKERING GOVERNOR CO.

For more information circle **42** on inquiry card.

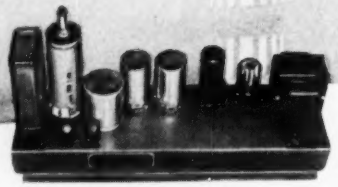


Reserve Power. Speedomax can operate at any speed from a whiz to a saunter, because balancing motors are two to four times more powerful than in any other present-day electronic controllers. A heavy load of control and signal cams makes no difference. The long Speedomax shaft and big case can accommodate a worlds-record assortment of such accessories.

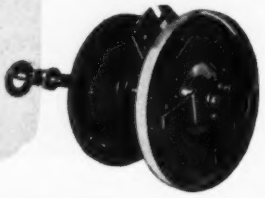
Reserve Construction. You may think all instruments are "delicate", until you look at a Speedomax. Then you'll see forgings and castings instead of stampings; cut, heat-treated gears instead of cast; ball bearings instead of sleeves. You'll see aluminum used, to save weight; parts made extra-strong to prevent deflections. You'll see, in detail after detail, how rigid construction gives rigid dependability.



Locked-in Synchronism. Synchronization of control, recording and signalling actions is permanently fixed because their actuating cams are locked on a common shaft. Obvious? Yes, but in this field a Speedomax exclusive.



Reserve Sensitivity. A change of one tenth of one percent of the range is picked up by Speedomax. The instrument therefore, never strains to keep its readings precise, even when the range is short.



Reserve "Cleanness" Speedomax has superb filtering and (when needed) shielding, but neither can guarantee that the electronic recorder's circuit will be unaffected by electronic "junk" from nearby motors, or other equipment. So, we provide a unique "clean" circuit design—and thereby cancel the junk that would otherwise slow down the balancing motor. Net effect is snappy and accurate recording action.

SPEEDOMAX® "Reserves"

ARE ALWAYS ON THE JOB!

● You get extra-fine performance, day-in and day-out, from Speedomax Recorders or Controllers because they are full of reserves to meet the "unusual" conditions which can and do come up so frequently. And these reserves of course give low maintenance as well as fine performance.

Why not inspect these evidences of quality the next time you need an automatic electronic potentiometer or bridge. See Catalog ND46(1) and (for circuitry) Tech. Pub. ND46(1). Address our nearest branch office, or 4955 Stenton Ave., Philadelphia 44, Pa.

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Editorial Comment

The Eighth National Instrument Conference and Exhibit

"Biggest and Best"

ONCE more it is proper to apply the expression "biggest and best" to an annual Instrument Conference and Exhibit. "Biggest" because nearly all of the significant numerical records were broken at this Conference and also at this Exhibit. "Best" because nearly all the intangible factors and nearly all the tangible things that go to make "quality" were *perceptibly* better at this Conference, and *visibly* better at this Exhibit, than at any of the seven previous Conferences and Exhibits.

For the third time—the first two being 1946 and 1947—this annual dual event was hotel-housed instead of convention-hall-housed. Two hotels were used. From Saturday September 19th (when the first committee meetings were held) until Saturday September 26th (when the behind-the-scenes work was nearly completed) the annual Conference was held in the Morrison; and the annual Exhibit was held in the Sherman, three city blocks away.

As usual, the host society was the Instrument Society of America. This year the participating organizations were: (1) the Instruments and Regulators Division of the American Society of Mechanical Engineers; (2) the Instruments and Measurements Committee of the American Institute of Electrical Engineers; (3) the Professional Group on Instrumentation of the Institute of Radio Engineers, and (4) the Scientific Apparatus Makers' Association.

It is too difficult to pick out, for special mention here, several of the nearly hundred technical papers—because at least sixty were "outstanding." It is a pleasure, however, to report—

that the ASME held a four-session symposium on Production Weighing and Control: fourteen papers!

that some ISA sessions on "Testing" instruments consisted mostly of excellent papers on calibration procedures;

that several astonishingly new papers were presented on the supposedly "old" subject of bridge circuits;

that the railroad industry (once called the "least receptive to Instrumentation") had several of its research and test engineers present papers;

that the "Medical Instrumentation Sessions" actually consisted of papers of wide interest;

that the first ISA session on "Analysis Instrumentation" was devoted entirely to the problems of continuous sampling methods and devices—four papers!—a significant milestone on the road to the manless factory;

that the Thursday morning ISA session on "Testing Instrumentation" was entirely devoted to analog and digital computing and data-processing systems—four papers!

Refinements in Analytical Instruments

It was at the St. Louis Exhibit in 1949 that most visitors were amazed to see for the first time spectrometric and other analytical instruments, costing tens of thousands of dollars apiece, sold practically "over the counter" like the pocket thermometers and other fully-commercialized well-known instruments in the adjoining booths on the same exhibit floor. Some visitors were even more amazed to learn, before the St. Louis Exhibit closed, that dozens of these costly new instruments had been avidly purchased. This year at Chicago, what was noteworthy was not the newness of analytical instruments but the fact that each major type was represented by more than one make; and the consequent fact that this competition had led to numerous refinements and user-conveniences. The mass spectrograph—five years ago a scientific laboratory apparatus—has become fully industrialized and is offered in several models, including one model especially designed for process control. So is the infrared spectrometer. So are x-ray diffraction instruments, electron diffraction instruments, x-ray fluorescence instruments, and other analytical instruments, all of which, only a few short years ago, were built one-at-a-time under the direct supervision and sometimes with the manual participation of their designers.

Analytical Instrument "Building Blocks"

A noticeable—and noteworthy—feature of the 1953-model analytical instruments is the speed with which a delicate laboratory apparatus originally built to order at enormous cost undergoes a series of modifications until it emerges as a commercially-available and relatively low-cost instrument. Principal reasons seem to be as follows:

(1) The 1953-model instrument company itself: a balanced team, accomplishing in weeks what grandfather's companies did in years.

(2) Demand from users who have at last won the ear of top management in their respective industries.

(3) The *physical* possibility of rapidly converting designs into actualities without the over-all project being held up by one detail after another. This physical possibility consists in the immediate availability of not only most of the requisite components but also some of the requisite subassemblies. This saving of time and effort is at its best in the field of electrical subassemblies, including numerous types of electronic components.

The "Plug-in" Idea in Process-control Instrumentation

Nearly twenty years have passed since the appearance of plug-in watthour meters for residences and plug-in wattmeters or ammeters for machine tools. About three quarters of a century has passed since the appearance of the railroad-car air-hose non-leak coupling. More than twenty years have passed since the installation of the first "console" form of hydroelectric plant control panel with miniature electrical instruments. The first commercially available pneumatic telemetering system was brought out in 1937.

A combination of these four ideas—and others!—gradually evolved, between 1937 and 1948, into various systems of connecting centralized control houses to "blind" automatic controllers located close to the points of measurement and to the valves which they commanded.

These early systems were custom-built; not until 1947 was the first "stack-form" pneumatic automatic controller commercialized to replace the "instrument-form" blind controllers.

And not until this 1953 Chicago Show do we suddenly find a *majority* of the old-established manufacturers of recorder-controllers exhibiting their new miniature indicators and recorders with the associated stack-form controllers located either at the back of the panel or at the points of measurement and control.

To instrument men concerned with process control, there was nothing more fascinating than these numerous exhibits of pneumatic control systems differing in details but all possessing in common the advantages of plug-in interchangeable parts and of complying with anti-wiring insurance rules while minimizing transmission lags.

The Most Useful "Competition"—Pneumatic, Hydraulic, Electrical and Electronic

Numerically, the manufacturers of pneumatic control systems predominated. Evidence of the continued growth

YOU CAN PUMP IN CONTROLLED VOLUME

HYDROCHLORIC ACID... ALL CONCENTRATIONS

CHLORINATED HYDROCARBONS

CORROSIVE METALLIC SALT SOLUTIONS

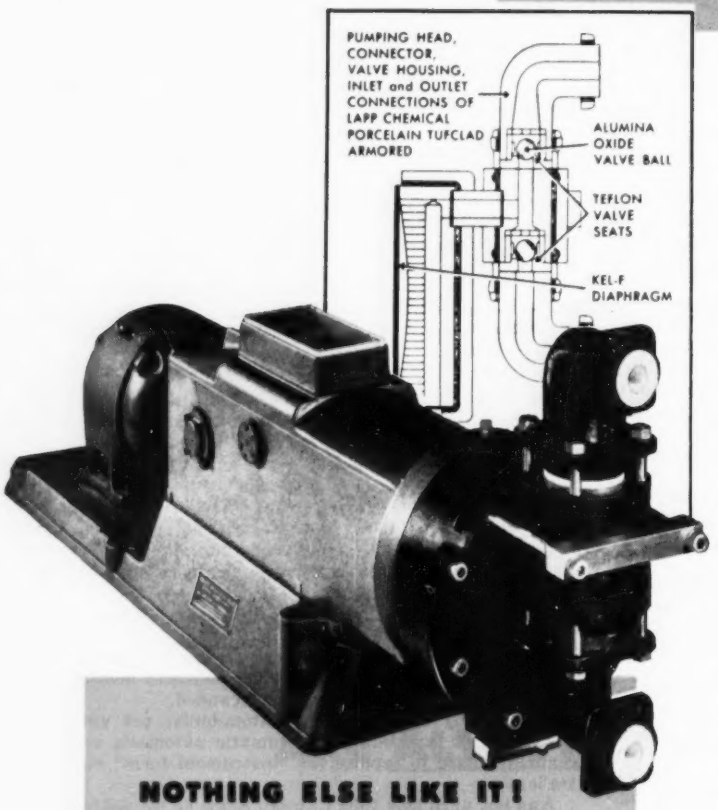
DILUTE ACIDS

MIXED ACIDS

WITH

Lapp PULSAFEEDER

COMPLETELY NON-METALLIC CONSTRUCTION


PUMPING HEAD, CONNECTOR, VALVE HOUSING, INLET and OUTLET CONNECTIONS OF LAPP CHEMICAL PORCELAIN TUFCLAD ARMORED
ALUMINA OXIDE VALVE BALL
TEFLON VALVE SEATS
KEL-F DIAPHRAGM

NOTHING ELSE LIKE IT!

Lapp Pulsafeeder is the combination piston-diaphragm pump for controlled-volume pumping of fluids. Reciprocating piston action provides positive displacement. But the piston pumps only an hydraulic medium, working against a diaphragm. A floating, balanced partition, the diaphragm isolates chemical being pumped from working pump parts —eliminates need for stuffing box or running seal. Pumping speed is constant; variable flow results from variation in piston-stroke length—controlled by manual hand-wheel, or, in Auto-Pneumatic models, by instrument air pressure responding to any instrument-measurable processing variable.

Solid Lapp Chemical Porcelain, combined with parts of alumina ceramic, teflon and Kel-F plastics, is used for the liquid end of this model of Lapp Pulsafeeder. All parts which can come in contact with liquid being pumped are non-metallic, chemically inert. Thus, positive-displacement metered pumping of "hard-to-handle" corrosive chemicals is made certain and permanently trouble-free.

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with typical applications, flow charts, description and specifications of models of various capacities and constructions. Inquiry Data Sheet included from which we can make specific engineering recommendation for your processing requirement. Write Lapp Insulator Co., Inc., Process Equipment Division, 122 Wilson Street, Le Roy, New York.

For more information circle **44** on inquiry card.

Two small corners of the huge 8th Annual ISA Exhibit.

of pneumatics was the showing of new tubings and even new tube-support brackets.

But, for enthusiasm, for fervent reminders of engineering facts that are too often forgotten, the hydraulic-system people were not surpassed.

And, to equally enthusiastic assertions, the electrical automatic-control system engineers added confident predictions of the inevitable future of "electronics." The important electrical and electronic innovations this year are the use of low-voltage microwattage direct current in the components located in hazardous areas, and the extraordinary convenience of plug-in assemblies.

It is generally agreed that the two most important elements of an automatic control system are: (1) the primary measuring element which first responds to changes in the controlled variable; and (2) the final control element. However, it was in the SIGNAL-AMPLIFYING ELEMENTS of many of the exhibited automatic control systems that electronic elements were utilized with resultant improvements in performance. As in preceding Shows, the chief improvement due to electron tubes was higher speed; and the chief practical advantage was quick low-cost replacement.

Control Valves and "Self-Ops"

Valve manufacturing is such an old branch of American industry that one seldom expects to find something absolutely new at every annual show. This year the temperature and pressure limits were pushed still higher; there were new materials, new quick-dismount and quick-assemble designs, and even new types of control valves for special applications such as pilot plants.

Parallel improvements were noted in the self-operated temperature and pressure controllers—those unsung devices which John S. Leslie termed "Simplified Instrumentation."

The "Atomic Age"

At the first Conference, at Pittsburgh in 1946, a session on Instrumentation for Atomic Energy was added at the last moment, but no commercial exhibit was devoted to this field. At Chicago in 1953, no visitor could doubt that we have entered the age of nuclear energy; not only were there various types of instruments for detecting and measuring all types of radioactivity, but there were industrial instruments utilizing nucleonic phenomena for continuously measuring thickness, density, liquid level, etc.

Industrial TV

Three manufacturers of wired TV displayed flexible industrial systems—including water-cooled cameras for peering into furnaces, remote-controlled cameras for dangerous areas, and sealed cameras for underwater use.

Two New Types of Flow-rate Meters

The principle of the electromagnetic flow-rate meter goes back to Faraday's experiments of 1831, but commercial models were not brought out until recent years. Now they seem to have reached the stage of full maturity, thanks to the spirit of competition which has led to the elimination of "bugs" in early models.

Another newcomer using an old principle is the mass-flow-rate meter. The old principle is the Coriolis effect. All of a sudden—within this last year—several companies have brought out Coriolis-based flow-rate meters which read *directly* in pounds per minute instead of gallons per minute. The simultaneous appearance of various makes—and of various models for liquids, for granular materials, etc.—should be quite pleasing to instrument men in numerous industries.

The Right Road Toward the Manless Factory

The right approach is to try to solve the multitude of "little" problems related to a particular type of complex plant. In most cases this means modifying individual controlled machines or flow units here and there—as well as instruments—in order to improve the coordination of individual units and the interlocking of individual instrument functions. It always is the kind of difficult job known for the last forty years as "application engineering" and recently renamed in various glittering ways.

A Humble Example of the Right Road

The example we pick out, from the many marvels displayed at the Chicago instrument exhibit, is the appearance of several improved systems of annunciators, signal lights, alarm gongs, etc. The improvements "look simple" and could have been made many years ago, but the market was not ready. In recent years the trend toward miniature control stations, graphic panels, consoles, etc., created a good market and then, in the good American way, competition among the makers of different systems led to the bringing out of more and more elaborate and ingenious systems for more and more complicated applications with more and more stages of alarm conditions.

These modern alarm systems are a far cry from the "high and low" alarm contacts stuck on indicating instruments as an afterthought in grandfather's day. In our opinion these "humble" alarm systems represent one of the paths that begin the Right Road to the Manless Factory.

Why? Because they make logical decisions. Individually trivial decisions, to be sure, but decisions that were not previously made by any one of the automatic controllers. Decisions, therefore, that previously were made only by the human being who supervised all of these automatic controllers. And, we repeat, *logical* decisions.

No, these alarm systems don't make the final decisions; but they are capable of several steps of *binary logic*, whereby they can be "taught" sequences that interlock not only in position but in time. Thus, they save much of the supervisor's time and rid him of many little worries.

We confidently predict that the next year's march on this Right Road will be the *automatic* correction, by means of binary-logical elements, of a few minor emergencies beyond the scope of the regular automatic controllers. A "giant brain"? No! Just a system of relays—each relay system designed for a particular type of multi-control-system central control room.

—MFB

The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, computing, metering and automatic control—in the form of concise technical descriptions.

FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 1787

PROCESS CONTROL (and not otherwise classified)

Ion-resonance-principle Mass Spectrometer

New mass spectrometer designed specifically to meet process instrumentation requirements utilizes principle of ion resnance; has continuous-sample inlet system for direct connection to a stream or process line. Its range is (approx.) 1 to 100 mass units. A programming device allows: automatic and repetitive continuous scanning of spectrum; manual scanning or selection of peak or peaks of a given mass; and, with minor modification, automatic monitoring of one or more peaks in sequence. In conventional mass spectrometers, all ions are accelerated to provide a constant-energy ion beam which is passed through a magnetic field where ions are deflected according to their mass-to-charge ratio (m/r). In new instrument, the ions are formed within the magnetic field and those of a specific mass are caused to follow a spiral path to a collector by applying a superposed r-f. electrostatic field. By controlling frequency, only ions of a definite m/r are caused to follow this spiral path while all others are drawn out of analyzing region. As frequency is varied, complete spectrum is scanned. Provision is made for addition of a recorder, an automatic computer, or process control circuitry. — *Special Products Section, General Electric Co., Schenectady 5, N. Y.*

631

For more information circle **301** on inquiry card.

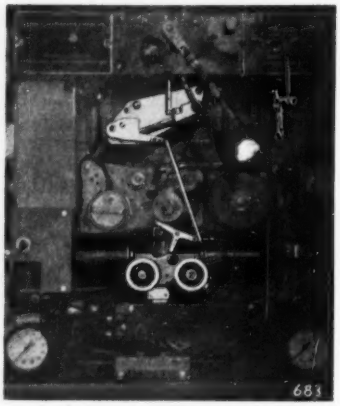
Microgram-sensitivity Balance

New models of "Micro Chemical Balance" have American-made sapphire knife edges and bearing planes instead of traditional agate. Sapphire is harder than agate and more uniform; can be polished flat or to a sharp edge without chipping; is nonhygroscopic; has a low coefficient of friction. Other improvements in new models include a redesigned, faster-acting beam, improved rider carrier, and new "Magni-Grad" optical projection system which makes it easy to read balance to one microgram.—*Wm. Ainsworth & Sons, 2151 Lawrence St., Denver 2, Colo.*

For more information circle **302** on inquiry card.

Narrow-band Pneumatic Controller

New models of maker's round-chart electronic potentiometers for pneumatic control are available with narrow proportional band plus automatic reset action. A new multiplying link-

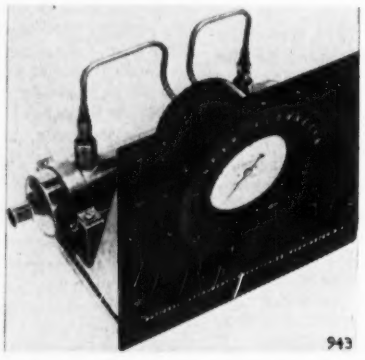

683

age provides proportional band settings from 1 percent to approx. 14 percent for full rotation of graduated proportional-band dial. A replacement kit for converting controllers already in use is available.—*Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.*

For more information circle **303** on inquiry card.

Gas Flowmeter

New "Model 30 Vol-O-Flo" dial-indicating gas flowmeter consists of a differential pressure gage across a linear pressure drop flow element;


943

measures flow-rate of gases at pressures up to 20 psig. For vacuum service it is operable to absolute pressures as low as 0.5 psia. (suction of 28 in. mercury). Temperature range —60 F. to 180 F., full-scale flow ranges from 0.003 to 30 cfm. for most gases.—*National Instrument Labs., Inc., 6108 Rhode Island Ave., Riverdale, Md.*

For more information circle **304** on inquiry card.

Dust-measuring Instruments

New in availability to U. S. users is "Casella" (English-made) line of dust-measuring instruments including: (1) "Cascade Impactor" for discriminatory low-jet-speed collection of airborne dusts by particle size; (2) "Settlement Dust Counter" for accurate collection of dust particles or air-borne bacteria; (3) "Thermal Precipitator" (illustrated) for sampling a wide variety of smoke, fumes and dusts, organic or inorganic; and (4) "Jet Dust Counter" for rapid or "snap" dust sampling at many points without interruption of mine or factory operations. "Thermal Precipitator" is described as well-suited for highly accurate sampling, particularly of dust clouds. Dust sample obtained is examined under a high-power, high-resolution microscope.—*Mine Safety Appliances Co., Braddock, Thomas and Meade Sts., Pittsburgh 8, Pa.*

808

For more information circle **305** on inquiry card.

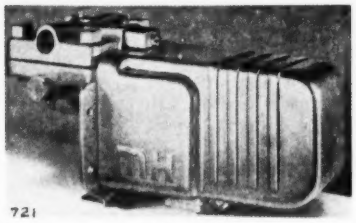
Analytical and Computing Services

New mass spectrometer analytical service solves specialized problems in chemical analysis, process monitoring, isotope-ratio determination, and high-precision leak detection, which occur too infrequently to justify purchase of mass spectrometer-type instruments. Available on a per-analysis basis is a permanently-staffed laboratory equipped with latest CEC instruments; Western Union and TWX installations speed reports of urgently-needed analyses. "Model 30-103 Electrical Computer" is available for rapid solution of simultaneous linear equations such as those resulting from mass-spectrometer or infrared applications. Similar sets of equations (in network, process vibration, and statistical analyses) can be solved on a fee basis. Reciprocal matrices of routine data can also be readily computed for subsequent use on desk calculators.—*Consolidated Engineering Corp., Pasadena 8, Calif.*

For more information circle **306** on inquiry card.

Flow-rate Transmitters

New "Differential Converter" units, for measurement of flow-rates in industrial processes, convert differential pressure into proportional air

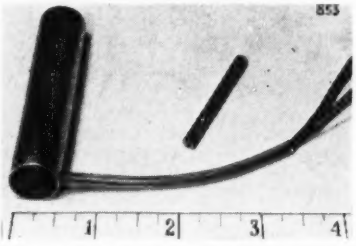


pressure to remote indicating, recording, or controlling instruments; are said to use one-sixth as much air as conventional nozzle-pressure transmitters and to be virtually unaffected by variations in air supply; do not use mercury; can be mounted on pipeline close to pressure taps.—*Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.*

For more information circle **307** on inquiry card.

Velocity Pickup

New "LVsyn" linear-motion velocity pickup, added to maker's line of linear displacement differential-transformer pickups, has a permanent-

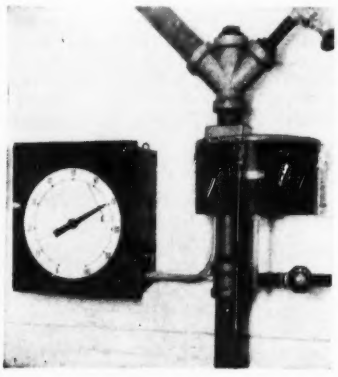


magnet core free to move along axis of coil assembly: relative velocity results in output signal. Maximum displacement ranges are from a few thousandths of an inch to several inches. Sensitivity is a function of size of pickup. For 1-in. stroke, sensitivity is 450 millivolts per inch per second.—*Control Components Co., 46 Walnut St., Brookline, Mass.*

For more information circle **308** on inquiry card.

Recording Turbidimeter

New recording turbidimeter continuously measures and records concentration of particles suspended in liquids; can be used with an audible



2 Types of WELCH

VACUUM GAUGES

McLeod Vacuum Gauge

No. 1453

High Vacuum Type

Tubes can be readily cleaned by direct mechanical operation where necessary, due to the unique construction of large openings directly in line with the capillary tubes.

Scale range 30 microns—Smallest calibration .005 micron.

Direct reading logarithmic scale.

Scales ruled on heavy white celluloid.

Mounted on all-metal heavy base.

Complete as shown, but without mercury.

EACH $160.00

Dubrovin Vacuum Gauge

DIRECT READING—ECONOMICAL—SIMPLE TO USE UNIQUE MAGNIFIED SCALE

This Gauge is principally a straight glass tube mounted on a metal base. The lower half of the tube is filled with mercury, in which is immersed an indicating float. As the air is evacuated through the outlet provided in the upper part of the glass tube, the indicator shows pressure variations directly on the scale.

No. 1451C

1451C. DUBROVIN GAUGE TYPE A table model, 20 mm. range, 6 to 1 scale, without mercury	Each, $44.50
1451E. DUBROVIN GAUGE TYPE B table model, 20 mm. range, 9 to 1 scale, without mercury	Each, $52.50
1451G. DUBROVIN GAUGE TYPE A wall model, 20 mm. range, 6 to 1 scale, without mercury	Each, $44.50
1451J. DUBROVIN GAUGE TYPE B wall model, 20 mm. range, 9 to 1 scale, without mercury	Each, $52.50

Also made from Pyrex brand tubing at the same prices.

W. M. WELCH SCIENTIFIC COMPANY

DIVISION OF W. M. WELCH MANUFACTURING COMPANY

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For more information circle **45** on inquiry card.

or visible alarm; is quite stable with respect to variations in photocell sensitivity, temperature, lamp brightness, line voltage, or color of the liquid. Two main components: (1) Sampling head contains the chamber through which liquid passes and a single light source which illuminates a photocell located on one side of chamber. Light source alternately shines directly on photocell and then at a right angle to photocell. (2) Circular-chart recorder, which measures electrically ratio of scattered to transmitted light. With maximum operating pressure of 100 psi. inside sampling head, turbidimeter has an accuracy of 5 percent of full scale and a precision of 3 percent of full scale. Range is adjustable in the field from 0-25 to 0-10,000 ppm. (silica scale). Cycle-time is 60 seconds.—*Special Products Section, General Electric Co., Schenectady 5, N. Y.*

For more information circle **309** on inquiry card.

Heat-flow Transducer

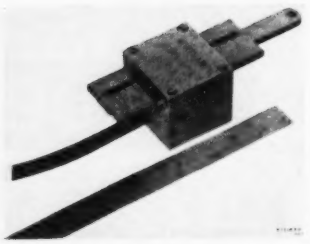
New "Model 200 Heat-Flow Transducer" features high linear electrical output relative to heat-flow gradient across transducer, resulting from a

large area density of silver-constantan thermocouple junctions whose output can be connected in various physical and electrical configurations depending upon requirements. Based on a unit 3/64 by 4.5 by 4.5 inches containing from 180 to 720 junctions plus a thermocouple to check ambient temperature, transducers are made in a range of sensitivities up to 6 btu/ft²/hr/mv. Each weighs approx. 1 oz.—*Beckman & Whitley, Inc.*, 930 *San Carlos Ave., San Carlos, Calif.*

For more information circle **310** on inquiry card.

Displacement Pickup

New "Model LP-1 Linear Position Transducer" converts linear motion or position into a proportional electrical signal for remote indication, recording or control, production inspection and gaging, etc. Unit is of magnetic reluctance type, moving slide controlling inductance difference between two coils. It will operate in a-c. carrier systems from 60 to 10,000 cps. with an accuracy of 1 percent of operating range and virtually unlimited resolution. When operated in a bridge circuit, full-scale output is plus-and-minus 40 mv./v. and maximum excitation is 7 volts. Its "fidelity" is high enough for oscillography. Slides giving travel ranges from 0.5 to 2.0 in. (plus and minus) are available with standard 1-in. case size. All electrical components are rigidly embedded in cavi-

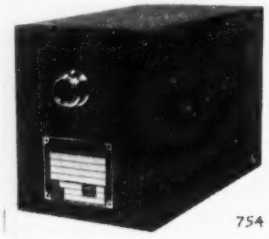


ties machined in case, permitting operation under extreme shock and vibration conditions. An alternate model, hermetically sealed for corrosion resistance, is available for operation in extreme ambient conditions and is recommended for process control and rocket test installations. A portable "Control Unit" with indicator for 115-volt 60-cps. operation, featuring 1 percent voltage regulation and standardizing circuit can be furnished.—*North American Instruments, Inc.*, 2420 *N. Lake Ave., Altadena, Calif.*

For more information circle **311** on inquiry card.

TV Camera Kit

New line of TV cameras for experimental and commercial use is announced. Illustrated is "Model 2AX," supplied as a kit in low-price field.



Other models include wired commercial units, with or without electronic view finders. All models can be coupled to home type receivers through 72-ohm coax to antenna terminals.—*K M Labs.*, 550 *Beverly Road, Teaneck, N. J.*

For more information circle **312** on inquiry card.

Aircraft Flight Recorder

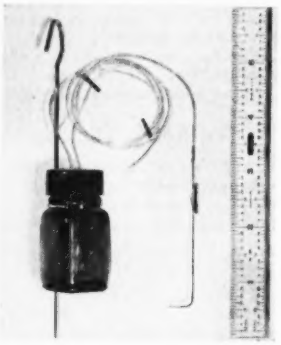
New "Model A Ryan Flight Recorder" records continuously for 300 hours altitude, airspeed, vertical acceleration and time (heading data optional); withstands exposure to 2000 F. for ½ hour without destruction of record, which consists of embossments on a 2.5-in. wide aluminum

tape, obviating need for photographic reproduction, magnetic play-back or other reading processes. Recorded data will not be destroyed by extended exposure to salt water. Unit is self-contained; has no electronic circuitry, therefore requires minimal maintenance; is unaffected by variation in power source voltage between 22 and 32 v. dc.; will continue to operate for 10 minutes in event of aircraft power failure.—*Mechanical Div., General Mills, Inc.*, 2003 *E. Hennepin Ave., Minneapolis* 13, *Minn.*

For more information circle **313** on inquiry card.

Recorder Pens

New "Cannon" (formerly "Chartomatic") "Meter Pens" are said to record for periods up to a year with one filling and virtually no attention.

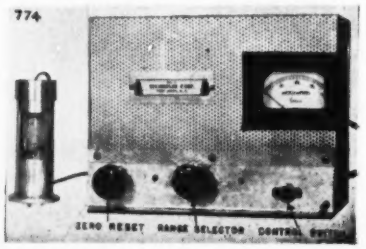


Uniform lines, contributing to accuracy, are produced by controlled ink flow: ink is supplied by capillary feed upward through a flexible plastic tube connected to a half-ounce reservoir suspended inside recorder case to protect ink from dust and atmospheric contamination. Rapid pen movements and atmospheric fluctuations have no effect, so that risk of unrecorded intervals is eliminated. New pens are available in various types for all standard recording instruments. Complete kits are available for field installation.—*American Meter Co.*, 1513 *Race St., Philadelphia* 2, *Pa.*

For more information circle **314** on inquiry card.

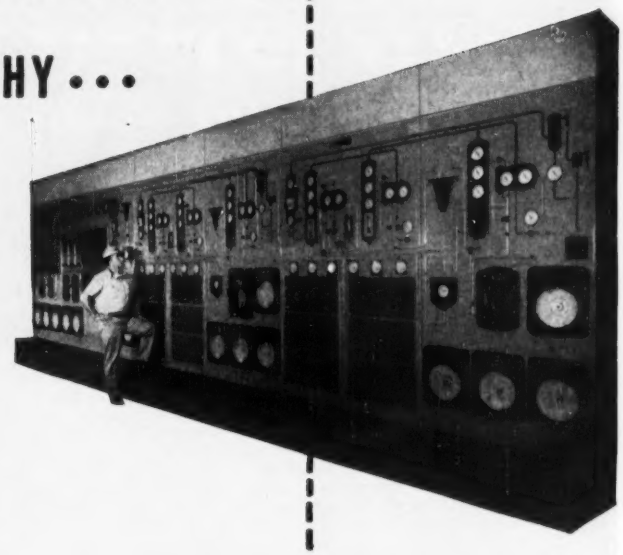
Photoelectric Relays and Photometers

New line of industrial photoelectric relays and photometers is announced. Relays are available in models specifically designed for: timing control; dust, soot and smoke control; turbidity control and alarm work; exposure control in x-ray, ultraviolet, infrared, and related work; safety alarm in danger areas; temperature control;



6 REASONS WHY...

PANELLIT is the largest builder of process control panels



1 **SPECIALIZED ENGINEERING . .** combining instrumentation and process experience, PANELLIT provides sound and economical engineering as a part of their service.

2 **ADVANCED STANDARDS OF CONSTRUCTION . . .** have distinguished PANELLIT in every detail of structure, finish, piping, terminal arrangements and serviceable behind-the-panel layouts.

3 **PIONEERING CONCEPTS OF INSTRUMENTATION . . .** the graphic control panel, miniature instrumentation, unitized annunciator systems, scanning and monitoring devices . . . all have been closely associated with PANELLIT.

4 **ORGANIZATIONAL FLEXIBILITY** . . . Few process control panels are ever shipped without changes. When "change orders" are received, PANELLIT moves quickly to carry them out . . . without confusion . . . without delay. Where others take weeks, PANELLIT takes hours.

5 **THE ONE MAN PLAN . . .** makes PANELLIT easy to work with. One project engineer stays with your job. There are no "pass along instructions" or "round about authority".

6 **INFORMATION SYSTEMS . . .** an advanced PANELLIT concept of the control panel has resulted in better process control. An *information system* filters information for the operator to know . . . and presents it in a manner that he may act quickly and instinctively. *Write for complete information.*

PANELLIT

INFORMATION SYSTEMS

PANELLIT, INC., 6312 N. BROADWAY

CHICAGO 40, ILLINOIS

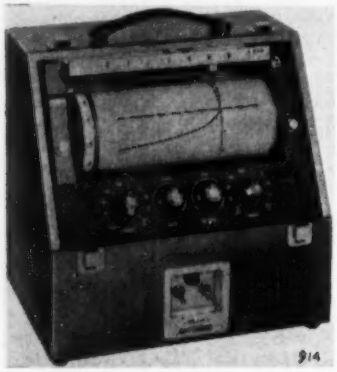
For more information circle **46** on inquiry card.

control and alarm duty in connection with solution concentration in detecting gases or analyzing gas mixtures; counting control; color-matching control; camera control. Photometers are available in models for many types of work. "Model PM-I-4," shown in photo, is specialized for measurement of radiation from glowing filament sources, offers four ranges of measurement: 0-0.001, 0-0.01, 0-0.1 and 0-1.0 lumen. Its "zero reset" control may be used to cancel dark-current effects and sustained tube noise, thereby isolating reading to incident radiation only; and, when particular interest is attached to different measurements, wide scope of reset may be used to zero a given radiation level with all departures from this level thereafter being registered as a needle swing on a scale of suitable sensitivity. One of new photometers responds to 0.001 microlumen of incident radiation. Maker also furnishes custom-made special constructions; for example, inclusion of a relay for control actions.—*Instruments Div., Techniflex Corp., Port Jervis, N. Y.*

For more information circle **315** on inquiry card.

X-Y Recorder and Automatic Curve Follower

New model of "Autograf," general-purpose portable 2-axis recorder, is available as an automatic curve follower which generates, as a voltage-divider setting, function Y from a graph relationship $Y=f(X)$. When used as an X-Y recorder, "Autograf" plots $Y=f(X)$ through two independent rebalancing servo-actuated recording axes from data reduced to electrical form; resulting cartesian

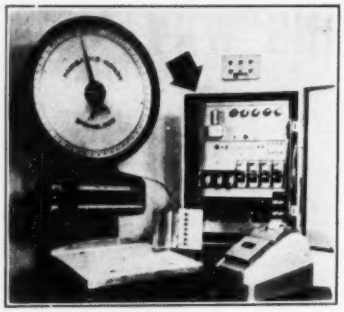


coordinate graph is traced in ink on standard 8½ x 11 in. graph paper. When instrument is used as a curve follower, pen is replaced with a pick-up stylus; curve to be reproduced is drawn with conducting ink on standard graph paper; and ink is energized with h-f. current. Pickup coil, sensing electromagnetic field radiated from graph line, drives pen servo so as to continuously position stylus over curve. This servo also drives a 3-turn helical voltage divider which supplies output (Y) information. Writing or reproducing rate: 10 in. per second.—*F. L. Moseley Co., 409 N. Fair Oaks Ave., Pasadena 3, Calif.*

For more information circle **316** on inquiry card.

Weight-printing Converter

New "ETS-7 Electronic Conversion Unit" records net weight readings directly from any dial scale and enters the information into business ma-



chines or IBM Units. It controls conveyor, monorail, or hopper delivery across scales; records weight readings at rate of one unit per second. Weights are itemized, sub-totaled, and totaled as desired; printed automatically on tape or business form. Information can also be stored, subtracted, multiplied, or extended. Any number of scales, business machines or IBM Units can be used simultaneously through one "ETS-7."—*Industrial Electronic Engineers, 3973 Lankershim Blvd., North Hollywood, Calif.*

For more information circle **317** on inquiry card.

Flame-failure Safeguard

New "Fireye Programming Control," for commercial-industrial gas, oil, or combination gas/oil burners, protects against flame-failure explo-

sions; provides complete automatic startup, operating, and shutdown control for any type of burner and a selection of programming times for three types of ignition operation to comply with Factory Mutual Laboratories' requirements.—*Combustion Control Corp., 718 Beacon St., Boston 15, Mass.*

For more information circle **318** on inquiry card.

Ultraviolet Lamp

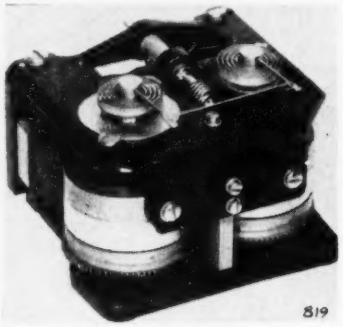
New "Blacklight Wand," added to maker's "Fluoretor" portable ultraviolet instruments, is a tubular unit resembling a large flashlight; weighs 28 oz. including two standard flashlight batteries. Ultraviolet generator is an instant-starting low-pressure mercury-vapor discharge tube of cold-

cathode type, shaped in a flat spiral to provide maximum output in range of 2537 Angstroms. A "longwave" (3650-63 A. u.) model also is offered. —*Menlo Research Laboratory, P. O. Box 522, Menlo Park, Calif.*

For more information circle **319** on inquiry card.

Magnetic-fluid-clutch Meter Positioner

New magnetic fluid clutch meter-positioner, already in operation as a pen-recording movement in airborne military gear, is made available for commercial use. Output shaft

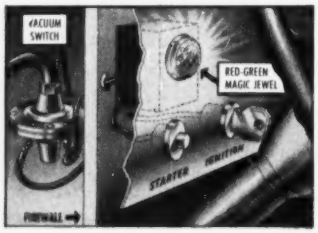


mechanism will deflect up to 120 deg. with maximum rated output torque of 5.25 oz-in. at 4 ma. Movement responds linearly to signals from 10 to 500 microamps, is accurate to within 5 percent and, as currently applied, has "flat" frequency response up to 5 cps. It comprises two small magnetic fluid clutches (0.46 lb. each) geared to rotate in opposition with their output shafts linked: output shaft mechanism responds to resultant developed torques of clutch input coil signals.—*Texas Instruments Inc., 6000 Lemmon Ave., Dallas 9, Texas.*

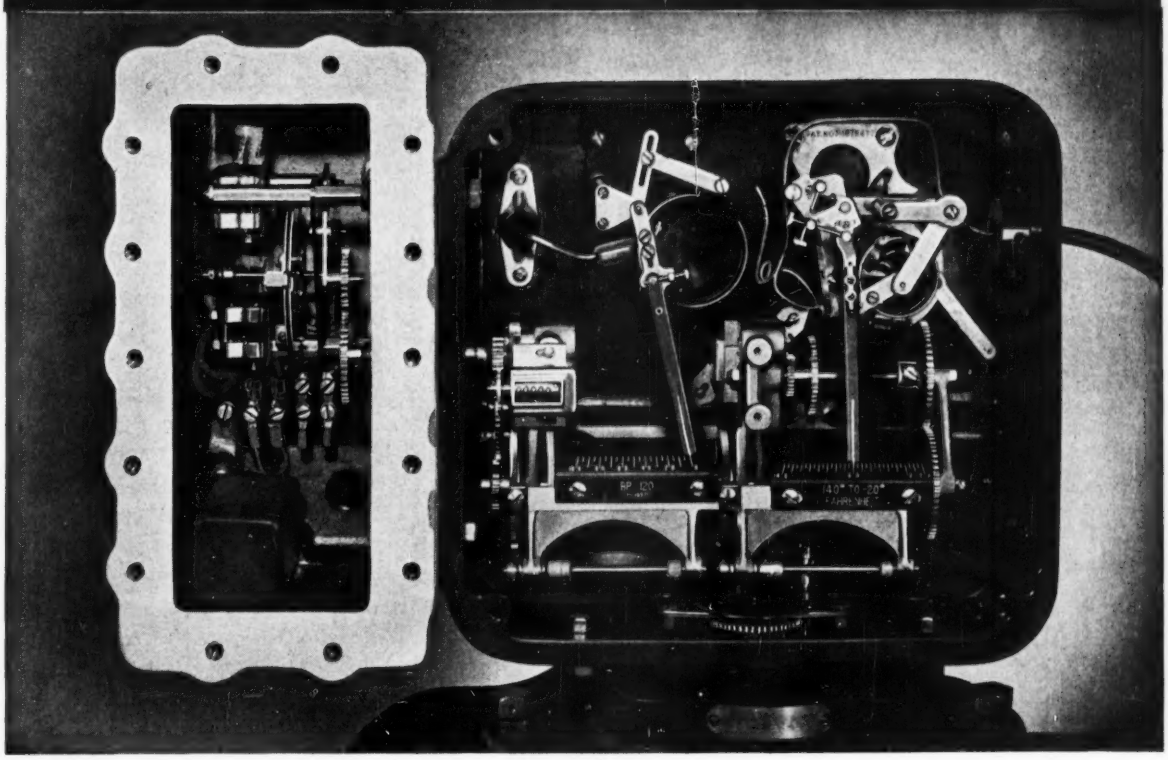
For more information circle **320** on inquiry card.

Automobile Efficiency Signal and Starter

New "Gyro-Start-Control" for automotive vehicles has a vacuum-operated switch connected to intake manifold, which flashes red dash light on loss of vacuum, and which ener-



NEW AMERICAN® TELECOUNTERS for base volume indexes



Now you can read base volume indexes at any remote location

American Telecounters accurately transmit Base Volume Index indications of gas quantities, computed to base temperature and base pressure conditions, to any convenient reading station. Remote indications are read from a compact reset-type counter which installs anywhere. The counter is actuated by electrical impulses received from the transmitter housed in the explosion-proof case on the side of the Base Volume Index.

- **Reset-Type Counter only 1 5/8" x 4"**
- **Explosion-Proof Transmitter Case**
- **Adapts to Large Capacity Ironcase Meters**
- **Reliable Transmission At All Times — Leased Wire, Private Wire Or Radio**
- **Power Pack Operates from Commercial 110 Volt, 60 Cycle, Single Phase Power Supply**

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AMERICAN® METER COMPANY
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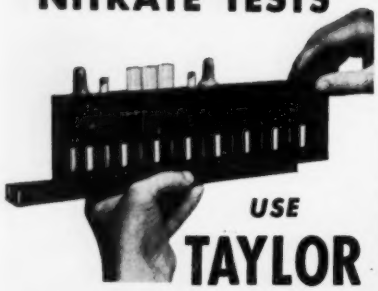
For more information circle 47 on inquiry card.

How to make

ACCURATE pH, CHLORINE, PHOSPHATE, NITRATE TESTS

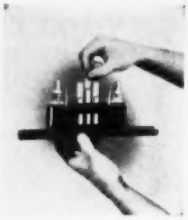


USE TAYLOR COMPARATORS

You can make many determinations in seconds . . . longest take only two minutes. Taylor Sets are lightweight, easy to carry for on-the-spot tests, or you can use them in the lab. Each set complete with accessories and reagents.

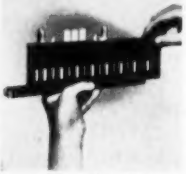
Easy as **A • B • C**

A. Fill three test tubes with sample to be tested and place them in the base.



B. Add reagent to middle tube only.

C. Place color slide on base, move across until colors match, and . . . THERE'S THE VALUE!



Guaranteed Color Standards!

Sealed-in-plastic color standards carry an unconditional guarantee against fading that gives you complete freedom from mechanical inaccuracy in making determinations. No single standards to handle. Each slide contains a complete set of standards for any one determination.

SEE YOUR DEALER . . . for equipment. Write direct for FREE HANDBOOK on pH and Chlorine control in 34 basic industries. Also illustrates and describes all Taylor Sets.

W. A. TAYLOR AND CO.
416 RODGERS FORGE RD • BALTIMORE 4, MD

For more information circle **48** on inquiry card.

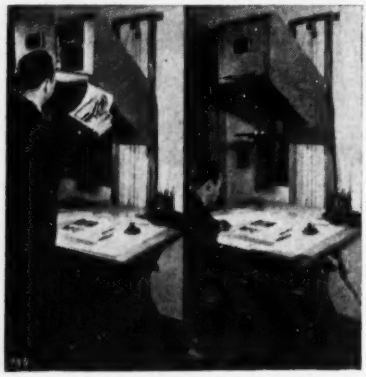
NEW INSTRUMENTS

gizes starter solenoid if motor stalls. (Restarting circuit remains inoperative until transmission is put in neutral.) Under normal running conditions, indicator light shows green, but will turn red to show any of several mechanical deficiencies. Device can be easily installed by anyone. Instructions are included with each unit.—*Gyro Control Co., 9244 W. Olympic Blvd., Beverly Hills, Calif.*

For more information circle **321** on inquiry card.

Image Projector

New "Model 44 Art-O-Graph" low-cost image projector casts bright, sharp, perfectly-scaled images of illustrations, photos, physical objects

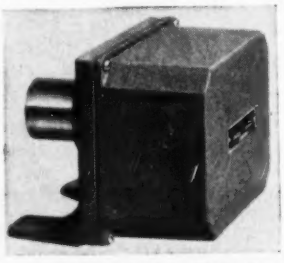


or color transparencies directly on drawing table; will enlarge more than four times and reduce more than four times; takes up no floor space but makes use of "dead" overhead space: is set up over a regular drawing table and its controls are located under drawing table. Specially-engineered hard-coated lens, counter-balanced carriage, and front-surface mirror are among features. Unit is shipped completely assembled, ready for use.—*J. A. Engel Inc., 624 Syndicate Bldg., Minneapolis 2, Minn.*

For more information circle **322** on inquiry card.

"Fail Safe" Photoelectric Controller

New "Type F Control," for protective type applications such as level, travel limit, combustion, smoke detection, etc., "fails safe" in that plate



relay is energized when light beam is on phototube and all tubes are operating; interruption of light beam or failure of lamp or a tube deenergizes plate relay to open (or close) a circuit. Among features: speeds to 1200 operations per minute, sensitivity adjustment, choice of built-in or remote photoelectric head and wide selection of light sources.—*The Autotron Co., Box 722, Danville, Ill.*

For more information circle **323** on inquiry card.

Pressure, Flow, Direction and Temperature Probes

New line of probes for use in gas streams comprises: (1) standard production models for temperature, pressure, flow-rate and flow-direction—

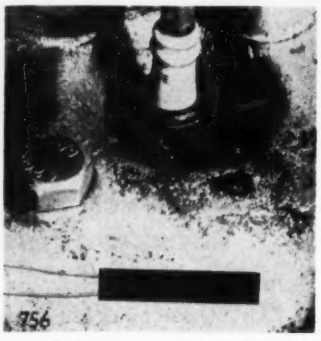
single-point probes in various forms, and "averaging" or "rake" probes—and (2) special models made to order for extraordinary applications in jet engines, in nuclear-energy heat-transfer apparatus, etc.—*Aero Research Instrument Co., 1901 N. Hermitage Ave., Chicago 22, Ill.*

For more information circle **324** on inquiry card.

TEMPERATURE

Surface Temperature Recording Systems

New combination is announced, of "RdF Stikon" resistance-thermometer elements and "ElectroniK" self-bal-

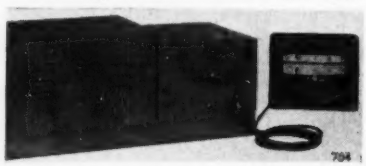


ancing bridge recorder. "Stikon" elements are fine-wire grids bonded into wafers of Bakelite or nitrocellulose cement and paper, in sizes as small as 0.75 x 0.32 in. and thickness under 0.006 in.—*Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.*

For more information circle **325** on inquiry card.

Temperature Controller

New "Model JS Stepless Temperature Controller" is not of "on-or-off" type but supplies only enough power to heating element to hold set tem-



Circle **49** on inquiry card. ⟶

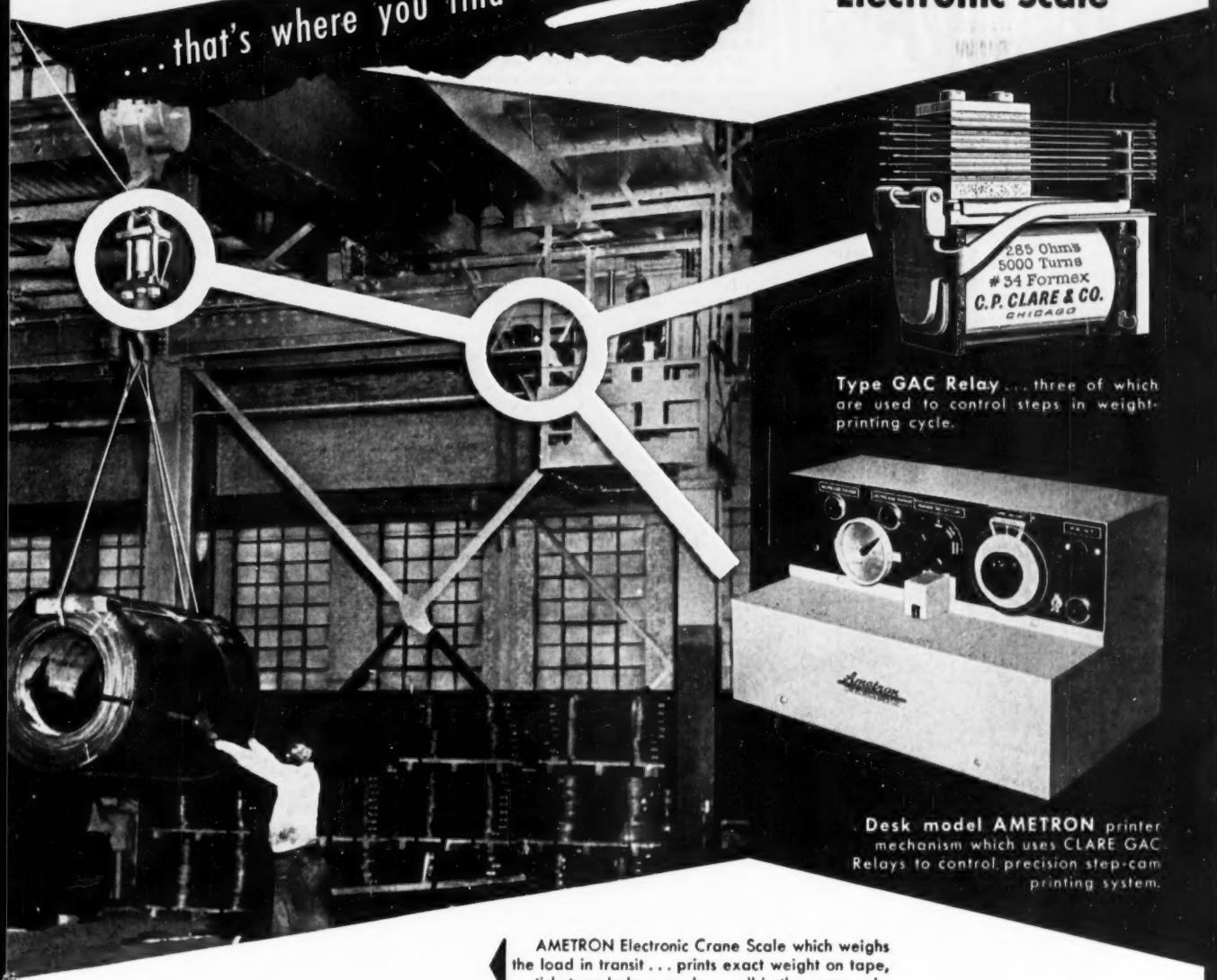
Where ordinary relays won't do...

...that's where you find CLARE RELAYS

For example—the

AMETRON

Electronic Scale



Type GAC Relay . . . three of which are used to control steps in weight-printing cycle.

Desk model AMETRON printer mechanism which uses CLARE GAC Relays to control precision step-cam printing system.

AMETRON Electronic Crane Scale which weighs the load in transit . . . prints exact weight on tape, tickets or ledger cards . . . all in the crane cab.

Because weighing and transporting operations can be performed simultaneously, the Streeter-Amet AMETRON Electronic Scale permits tremendous savings in production time.

Such savings can only be maintained, however, because all the components of this highly specialized device can be counted on for sustained accuracy under heavy-duty operating conditions . . . with minimum maintenance requirements.

Ordinary relays would not meet such rugged operating conditions. Clare Relays were selected by Streeter-Amet engineers because of:

- ★ **Sustained accuracy of operation under difficult operating conditions.**
- ★ **Ability to withstand wide variations in temperature range.**
- ★ **Long-life dependability.**
- ★ **Small size for compact installation.**

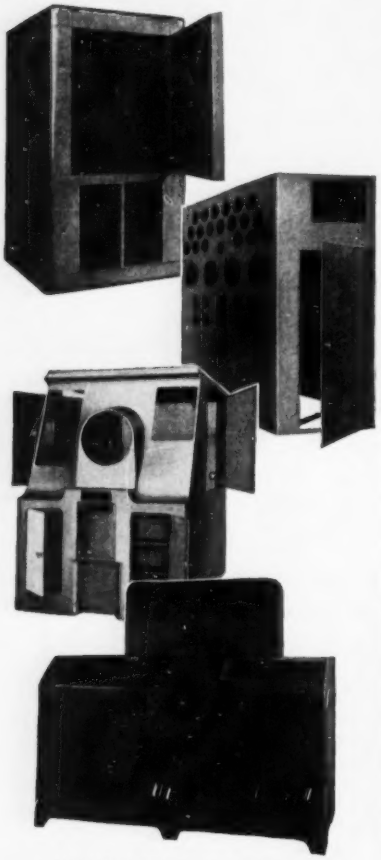
Clare Relays have been the choice of Streeter-Amet engineers for many years in every type of electronic weighing device. If you manufacture a precise, quality product . . . one which calls for utmost relay performance . . . it will pay you to investigate Clare Relays. Sales engineers, fully experienced in every type of relay problem, are located in principal cities for consultation. Call them . . . or write C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13. Cable address: CLARELAY.

***FIRST* IN THE INDUSTRIAL FIELD**

CLARE RELAYS

OUR FIRST GOAL IN FABRICATING INSTRUMENT MOUNTING STRUCTURES

Artisans and engineers at Littleford understand and meet exacting requirements of manufacturers of electrical and hydraulic control equipment. Hence Littleford has become a foremost builder of such cabinets, panels, control boards, steel cubicles, mechanism boxes. Get structures right—get Littleford!



FABRICATORS OF PLATE AND SHEET METALS

LITTLEFORD

LITTLEFORD BROS., INC.
424 E. Pearl St., Cincinnati 2, Ohio

For more information circle **50** on inquiry card.

perature: heater only operates at full power on initial temperature rise. Two sections make up system (except in higher capacity units with intermediate amplification). One section contains temperature indicator, parts of instrument control circuit and control pilot lights; other contains heavier parts of controller circuit. Only one vacuum tube: #6BL7-GT, available at TV and radio service shops. Models are available to handle loads from 300 va. to 110 kva.—*West Instrument Corp., 525 N. Noble St., Chicago 22, Ill.*

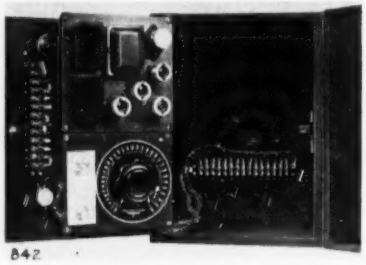
For more information circle **326** on inquiry card.

Temperature Controller

New "077" electronic temperature controller employs resistance thermometer primary element; provides on-off, two-position, floating or proportioning mode of control. Chief external feature is a pair of signal lights: green light glows when bulb temperature is below set point, red when above, both are out when temperature is "at" set point. New controller is available in single-point model, also in cascade control models utilizing two bulbs; both models available in three ranges: –20 to 220 F.; –20 to 300 F., and –100 to 600 F.—*Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.*

842

842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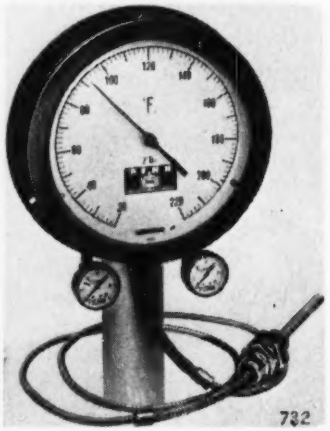
For more information circle **327** on inquiry card.

Indicating Temperature Pneumatic Transmitter

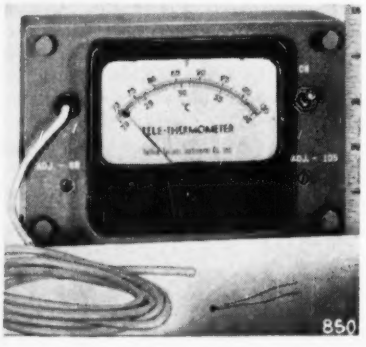
New indicating temperature transmitter comprises an 8-in. dial thermometer and maker's pneumatic transmitter; is suitable for outdoor unprotected installation; may be mounted on wall bracket, panel, or 2-in. pipe. Dial thermometer has mercury-filled thermal system, is available in ranges from –40 F. to 1000 F., with a wide variety of bulbs and sockets. Standard air output range of pneumatic transmitter is 3 to 15 psig. (other ranges available). Any number of receivers can be operated by a single transmitter. Transmitter embodies maker's "worm plate" construction which minimizes number of piping connections. Both nozzle and restriction are "jeweled"; and the always-accessible restriction-cleaning device permits cleaning restriction while unit is in service. This is said to be the only routine maintenance; and can be done without removing any protective covering.—*Penn Industrial Instrument Corp., 4110 Haverford Ave., Philadelphia 4, Pa.*


732

For more information circle **328** on inquiry card.

Thermistor Thermometer

New "Tele-Thermometer" utilizes a thermistor primary element for range from 68 F. to 105 F., has dial calibrated in F. and C. Nominally, readings are accurate to 0.25 C.; after careful calibration they can be brought to accuracy of 0.1 C. Thermistor probe is at tip of 6-ft. wire in waterproof plastic sheath. Silastic sheathing is available for applications where autoclaving of probe and lead is desirable. Circuit is essentially a



850

Now!
Transient-free test voltages down to 0.01 cps!

Versatile, general purpose generator for subsonic and audio work! Continuously variable, 0.01 to 1,000 cps, 5 bands. High stability, distortion less than 1%. Radical new circuitry offers sine, square and triangular waves.

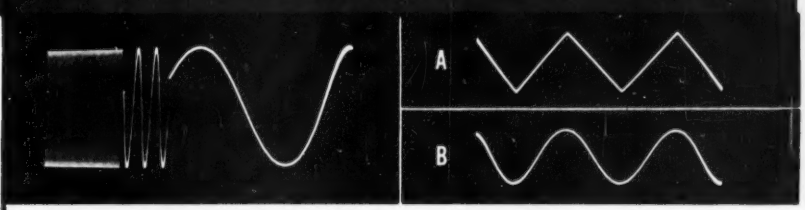


Figure 1. Oscillogram shows freedom from transients as output frequency is changed.

Figure 2. Oscillogram of (a) triangular wave applied to shaping circuit and (b) resulting sine wave.

SPECIFICATIONS

-hp- 202A Low Frequency Function Generator

FREQUENCY RANGE: 0.01 to 1,000 cps in five decade ranges.

DIAL ACCURACY: Within 2%.

FREQUENCY STABILITY: Within 1% including warm-up drift.

OUTPUT WAVEFORMS: Sinusoidal, square, and triangular.

MAXIMUM OUTPUT VOLTAGE: At least 30 volts peak-to-peak across rated load for all three waveforms.

DISTORTION: Less than 1% RMS distortion in sine wave output.

OUTPUT SYSTEM: Can be operated either balanced or single-ended. Output system is direct-coupled; dc level of output voltage remains stable over long periods of time. Adjustment available from front panel balances out of any dc.

FREQUENCY RESPONSE: Constant within 1 db.

HUM LEVEL: Less than 0.1% of maximum output.

SYNC PULSE: 5 volts peak, less than 10 μsec duration. Sync pulse occurs at crest of sine and triangular wave output.

POWER: 115-volt, 50/60 cycles, 175 watts.

DIMENSIONS: 10½" high, 19" wide, 13" deep.

PRICE: $450.00 f.o.b. Palo Alto, California. End frames, for table use, $5.00 per pair f.o.b. factory. (Specify No. 17.)

Data subject to change without notice.

–hp– 202A Low Frequency Function Generator offers you a compact, convenient and versatile source of transient-free test voltages between 1,000 and 0.01 cps. It provides virtually distortion-free signals for vibration studies, servo applications, medical and geophysical work, and other subsonic and audio problems. For such applications, the equipment generates 3 wave forms: sine, square and triangular. (Desired wave form is selected on front panel switch.) Output is 30 volts peak-to-peak for all 3 wave forms.

NEW CIRCUIT CONCEPT

–hp– 202A differs from conventional low-frequency oscillators in that the sine wave is electronically synthesized. A controlled bi-stable circuit generates a rectangular wave. This wave is passed through a special integrator providing a true triangular wave (Figure 2a). The triangular wave then enters a shaping circuit developed by *–hp–*. Here 6 duo-diodes modify or "shape" the peaks and provide a true sine wave with distortion of less than 1% (Figure 2b). This synthesizing circuit provides virtually transient-free output even when range switch is operated or frequency is rapidly varied. This circuit also maintains the amplitude constant under all conditions. It is not necessary to wait long periods for the circuit to stabilize at a new level as with conventional oscillators.

OTHER FEATURES

The output system of *–hp–* 202A is fully floating with respect to ground. May be used to supply a balanced voltage or either terminal may be grounded. It will deliver 10 v RMS to a load of 5,000 ohms or greater; internal impedance, however, is only 100 ohms. There are no coupling capacitors in the output system, and a high degree of dc balance is achieved by means of a special circuit.

-hp- field engineers, in most major cities, have complete details. Or, write direct.

HEWLETT-PACKARD CO.

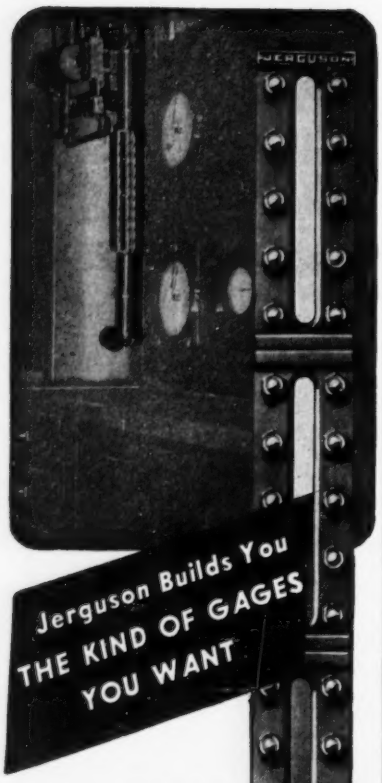
2325C Page Mill Road • Palo Alto, Calif.

Export: FRAZAR & HANSEN, LTD.

San Francisco • Los Angeles • New York

HEWLETT-PACKARD hp INSTRUMENTS

For more information circle **51** on inquiry card.



Jerguson Transparent Gage

You can get the kind of gages YOU WANT when you take your gage problems to Jerguson.

If you want a special gage or valve, or an adaptation of some standard one for a particular need, we'll give it to you. Our technically trained engineers have the ability, the know-how and the WILLINGNESS to pitch in and help you solve your problems.

Standard gages and valves, of course, are available at Jerguson's in the most complete and varied line offered anywhere.

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Gages and Valves for the Observation of Liquids and Levels

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100 Fellsway, Somerville 45, Mass.
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Pétrole Service, Paris, France

For more information circle **52** on inquiry card.

NEW INSTRUMENTS

balanced Wheatstone bridge. Power is supplied by a "D" size flashlight battery (average service life one year). Units may be provided (on order) with custom temperature scales or ranges, or in multiple-channel models.—*Yellow Springs Instrument Co., Yellow Springs, Ohio.*

For more information circle **329** on inquiry card.

Thermoscopic Materials

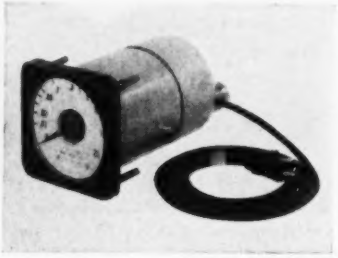
New "Tempilstiks," "Tempilag" and "Tempil Pellets" have been added to indicate 525 F. between the 500 and 600 F. materials already available.—*Tempil Corp., 11 W. 25th St., New York 10, N. Y.*

For more information circle **330** on inquiry card.

PRESSURE AND VACUUM

Vacuum Gage

New vacuum gage is complete in itself, its pointer directly coupled to deflecting member of measuring system. Principle is molecular "drag"



between two coaxially-mounted cylinders. One cylinder—the rotor—is driven at 3600 rpm. by a Telechron and imparts a momentum to those gas molecules in the space between it and the other cylinder. These molecules tend to rotate the other cylinder—the armature—which is spring-restrained and magnetically damped to minimize pointer oscillation. Resultant deflection is proportional to energy transfer, which is proportional to number of gas molecules in the space between rotor and armature.—i.e. to pressure. Instrument is available in two types, both covering range of 0 to 20 mm. of mercury column balancing dry-air absolute pressure. Models are identical except for scale markings: one has a non-linear scale calibrated directly in absolute pressure units for dry air; the other model has a linear scale to be calibrated by user for the gas in each vacuum system to be measured—a necessity because the same graduation near mid-scale would represent (to give an extreme example) 0.05 mm. Hg for xenon and 100 mm. Hg for hydrogen. This characteristic makes new gage applicable to an exceptionally wide range of absolute-pressure measurements. Jewel bearings and lifetime-lubrication ball bearings assure minimal maintenance. —*Apparatus Sales Dep't, General Electric Co., Schenectady 5, N. Y.*

For more information circle **331** on inquiry card.

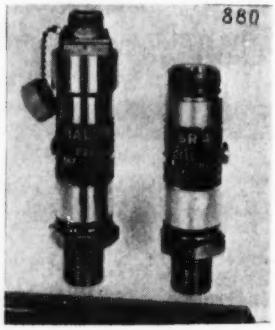
Cleanout Manometers

Two new lines of U-type cleanout manometers are announced. "Model BU" manometers have a Pyrex glass U-tube with packings at top; are available in 8 sizes from 6-in. to 50-in. range. "Model BS" manometers have two straight Pyrex glass tubes with packings at both ends and a cross connection in lower head; are available in 13 sizes from 6-in. to 100-in. range. In both, tubes are protected at sides and back by a channel-section steel case. Connections are made to upper head; and removal of a single screw permits case and glass tubing to be removed for cleaning without disturbing pipe connections.—*King Engineering Corp., Box 260, Ann Arbor, Mich.*

For more information circle **332** on inquiry card.

Pressure Pickups

New "Type HF" high-frequency pressure cells are of five standard capacities: 1000, 2000, 5000, 10,000, and 20,000 psi. (other capacities

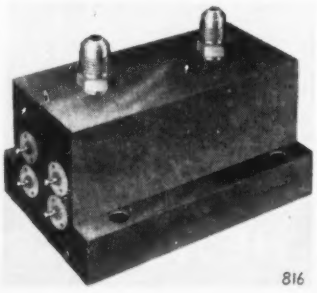


available). Cells consist of a pressure-sensitive tube with SR-4 strain gages bonded on outside. Cells may be connected to potentiometer type indicator or recorder, or to an oscilloscope or oscillograph for high-frequency response. Upper frequency response is almost never limited by pressure cell but by cavity resonance of tank or piping connected to it.—*Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pa.*

For more information circle **333** on inquiry card.

Pressure Pickup

New "Inductive-type Pressure Transducer" measures differential, gage or absolute pressures to 30 psi.; has resolution of 0.06 percent of full scale or better; is accurate to within 1 percent of full scale or better; is especially suitable for aircraft, guided



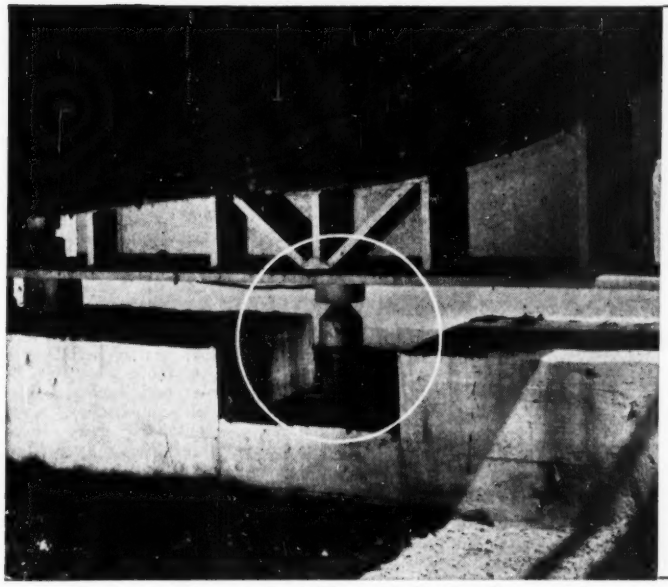
At the CHEM SHOW

...SEE THE LATEST IN PROCESS INSTRUMENTATION

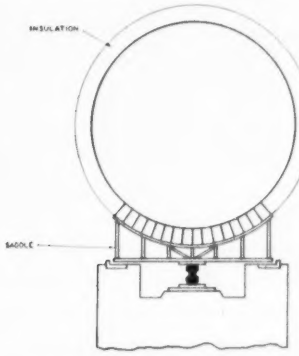
You'll find us there at Booth 36 with a 30-foot display ranging from simple indicating instruments to a section of graphic panel. Pictured below is the answer to just one type of problem in which you may be interested—accurately measuring the weight of chlorine in tanks. There are many other applications throughout the industry where Taylor Volumetric Load Measuring Elements are proving invaluable, such as measuring the tension on a conveyor belt or the thrust on a bearing. These instruments can be used for tension and compression loads. They're highly accurate and sensitive, and recent developments afford a wide variety of ranges, greater range suppression, greater over-range protection and greater energy for positioning the pen or actuating a control mechanism.

If you can't make the show, call your Taylor Field Engineer or write for **Bulletin 98232.** Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada.

Instruments for indicating, recording and controlling temperature, pressure, flow, liquid level, speed, density, load and humidity.



Spool type Volumetric Load Element indicating direct weight of chlorine in tanks. (0-80,000 *lbs.*)



SPOOL TYPE LOAD MEASURING ELEMENT

Range limits: 0-250,000 lbs. for compression loads, maximum load not to exceed 400,000 lbs. Applicable to horizontal or vertical tanks containing corrosives or solids, which make conventional level measuring devices impractical. Tension loads 0-30,000 lbs.

ALSO ON DISPLAY

★ **A section of graphic panel,** demonstrating the plug-in TRANSET* System's outstanding versatility. Both sides fully accessible for demonstration.

★ **FLEX-O-TIMER* Time Cycle Controller,** operating a multiplicity of electric and pneumatic functions in accordance with the requirements of a process.

★ **An animated Evaporator Control System** depicting instrumentation for fully automatic operation.

★ **TRANSAIRE* Temperature, Pressure and Differential Pressure Transmitters.** The remarkably fast speed of response of the TRANSAIRE temperature system is demonstrated.

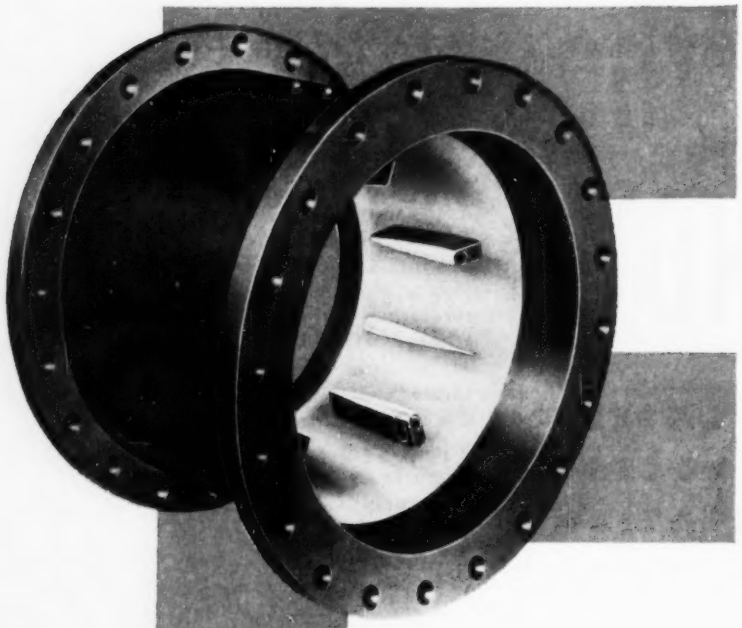
★ **A wide variety** of indicating, recording and controlling instruments.

*Reg. U.S. Pat. Off.

TAYLOR INSTRUMENTS MEAN ACCURACY FIRST

For more information circle **53** on inquiry card.

FOR ACCURACY IN METERING



CHOOSE A FLOW TUBE

Flow Tubes are furnished with head capacity curves based on laboratory tests. For unusual piping arrangements, special tests can be run simulating actual conditions. The data furnished with each Flow Tube makes exceptional metering accuracy possible.

Flow Tubes have many other plus values — they're compact, comparatively light weight, and are easy to install since they require minimum straight runs entering and following. And, Flow Tubes are available in types and D/d ratios to provide differentials that can be accurately measured with the least head loss.

That's why Flow Tubes are being successfully used in scores of installations metering the flow of liquids and wet or dry gases. Available in all pipe sizes and suitable metals. They can be furnished with or without suitable secondary indicating, recording or totalizing instruments. For further information, write for your Flow Tube Data File. For specific recommendations, send us necessary flow data.

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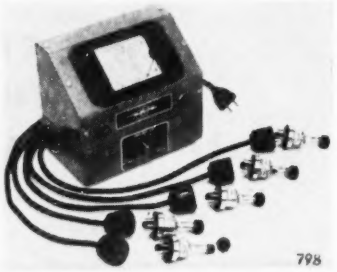
For more information circle **54** on inquiry card.

missile and industrial applications. Excitation voltage: 6 to 115 v.ac. from 100 to several thousand cps.; natural frequency: 1000 cps. and upwards depending upon application; output voltage: millivolts to several volts depending on input voltage selected; acceleration influence: 0.02 percent or less per *G.—Instruments Div., Sweeney Engineering Co.*, 3825 *Willat Ave., Culver City, Calif.*

For more information circle **334** on inquiry card.

Five-point Vacuum Gage

New model of maker's vacuum gage has switching unit to monitor as many as five positions in a vacuum system. Calibration is not affected



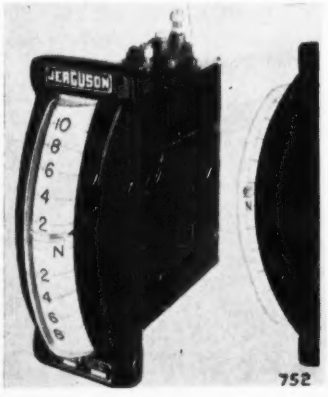
by length of cable from indicator to gage tubes. Continuous readings may be made without affecting pressure in system. Range is 1-1000 microns Hg.—*Hastings Instrument Co., Inc., Hampton, Virginia.*

For more information circle **335** on inquiry card

LEVEL

Liquid Level Gage

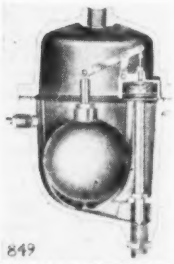
New "Convex Scale Truscale Remote Reading Gage" permits full 180-deg. visibility; makes it possible to read liquid level from anywhere in control room from which gage cover can be seen. Scale markings are on convex face. Indicator goes clear around convex surface. Compensated manometric gage meets new interpretation of boiler code for WSP of 900 psi. or higher. Accuracy is 0.5 percent. Models available for any pressure and range. Light and horn alarm signals, as well as "Truscale



Repeaters" for repeating gage reading at auxiliary points, are available. —*Jerguson Gage & Valve Co.*, 80 *Fellsway, Somerville* 45, *Mass.*

For more information circle **336** on inquiry card.

Automatic Drain

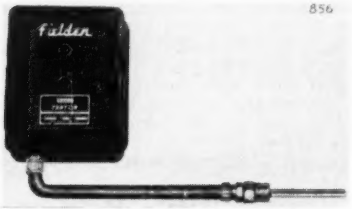


New "Series 1070" float-operated sump drain has 250-gph. capacity; incorporates a leak-proof cast-aluminum float; is actuated by accumulation of contaminants but actual discharge is by pressure of compressed air in tank or sump: float triggers a device which uses air pressure to open port in bottom. Same drain unit is part of new Automatic Separators for air lines, interrupted or continuous flow. These units contain a condensation chamber and filter to produce large volumes of clean dry air with no significant pressure drop. —*Wilkerson Corp.*, 1667 *W. Girard, Englewood, Colo.*

For more information circle **337** on inquiry card.

Automatic Level Controller

New "Tektor Level Control," capacitance unit with no moving parts, operates on 115 v. ac.; provides control as close as 1/16 in. of liquid,



divided solid, interface, conducting or non-conducting, wet or dry materials. Electrodes are available for use with pressures up to 2000 psi., temperatures up to 1500 F. "Models 101 and 102" are fail-safe, low level and high level respectively. New features include trimmer adjustment accessible without removing cover.—*Fielden Instrument Div., Robertshaw-Fulton Controls Co.*, 2920 *N. Fourth Street, Philadelphia* 33, *Pa.*

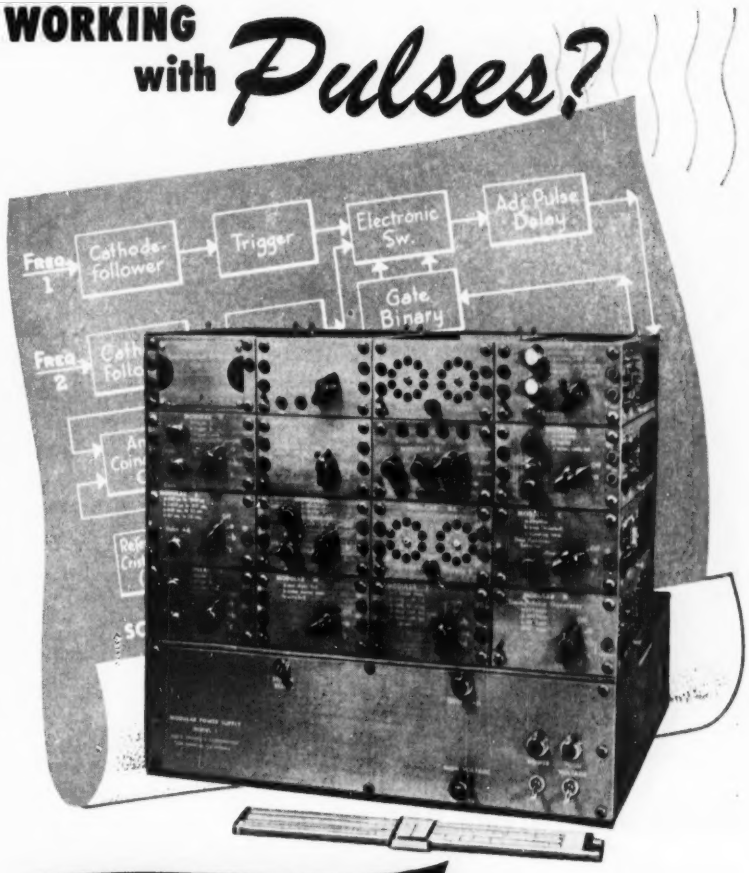
For more information circle **338** on inquiry card.

TIME and COUNT

Time Switches

New "Inter-Matic Series T670," time switches for controlling on-off cycles of one hour or less are available in 125- and 250-volt models; permit up to 12 "on-off" operations, each independently adjusted by trippers which provide variable settings ranging from 5 to 60 minutes. Tripper has a small time scale stamped on its face; and a time selector pointer is held in place by a small screw which is loosened and retightened to change

WORKING with *Pulses?*



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A basic electronic tool for design and use of pulse methods for information transmission, storage, and computation.

THE MODULAR SYSTEM consists of 16 highly flexible electrically and mechanically compatible units, together with a regulated power supply which are easily assembled and interconnected by patchcords to perform all the basic functions of digital pulse operations. Each unit (size: 2¾" high x 4½" wide x 9" long) performs a multiplicity of independent functions selectively, a complete system having a capability of 72 separate functions with as many as 31 functions simultaneously available. Design and development engineers can readily operate in the most complex systems at "block diagram" level without concern for circuit details.

- Saves engineering time by providing pre-constructed standard units: amplifiers, pulse-formers, frequency dividers, electronic counters.
- Complex instruments can be patched-up and operating within minutes after the need is conceived.
- Provides non-electronic laboratories with the advantages of pulse instrumentation.
- Using the Modulars as "logical boxes" design engineers can test concepts of non-vacuum tube computers.
- Together with an Oscilloscope serves as graphic training aid in digital pulse instruction.

Write today for descriptive brochure.

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For more information circle **55** on inquiry card.

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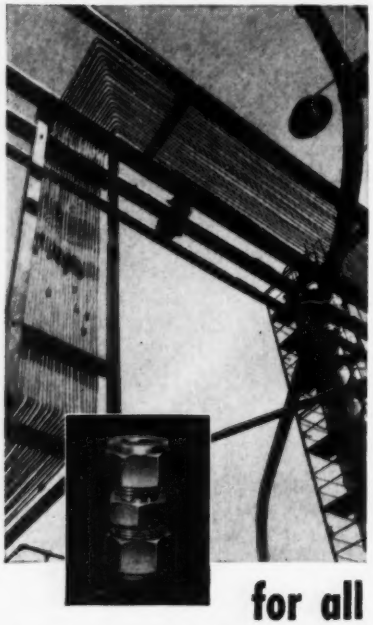
THE VITAL UNION



for all instrumentation and process piping lines

Swagelok Tube Fittings give you torque-free, leakproof seals at all connections, freeing you of those bothersome small leaks in instrumentation and process piping lines. Testing by "soaping" is unnecessary. Shutdowns are avoided.

Swagelok Tube Fittings are available in a wide variety of sizes from ⅛" up in brass, aluminum, steel, stainless steel and Monel. Other machinable metals can be furnished when required.

FREE—Send for the Swagelok Catalog today. Address Dept. 18

SWAGELOK FITTINGS AVAILABLE IN: BRASS, ALUMINUM, STEEL, STAINLESS STEEL, MONEL

CRAWFORD FITTING CO.

884 East 140th Street Cleveland 10, Ohio
Teletype CV-785

For more information circle **56** on inquiry card.

length of timing period. "T670" is said to be three switches in one: s-p.s-t. n-o.; s-p.s-t. n-c.; or s-p.d-t. alternately open and closed.—*International Register Co., 2624 W. Washington Blvd., Chicago 12, Ill.*

For more information circle **339** on inquiry card.

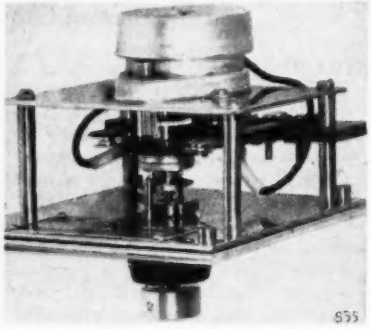
Laboratory Timer

New model of "Lab-Chron Timer," applicable wherever stop watches are used, has new counter, motor and switch. Counter has quadruple bearings for longer life. Motor is said to have double usual starting torque to give "instant" pick-up for accuracy. Two models; seconds-and-tenths; and minutes-and-hundredths. Reset by thumb wheel. Aluminum case. Start-and-stop switch rating 10 amps. —*Labline, Inc., 217 N. Desplaines St., Chicago 6, Ill.*

For more information circle **340** on inquiry card.

Automatic Timer

New "Model 437 Reset Timer" is driven by a synchronous motor; is designed to hold an electric circuit closed for a preset time after START

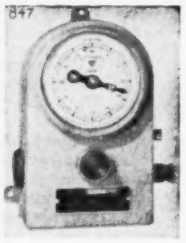


button is pushed; is particularly useful on molding machines, preheaters, etc., requiring repeated timed intervals. Setting (up to 150 sec.) remains fixed for repeated time intervals until dial pointer is re-set. N-o. contacts are rated at 20 amps. at 110 v.ac. Large-diameter START button makes operation easier on production runs. Other models are available with adjustable intervals up to 24 hours. —*Masco Products Co., 2119 Sepulveda Blvd., Los Angeles 25, Calif.*

For more information circle **341** on inquiry card.

Automatic Timer

New automatic timer for machines, processes, etc., is available in 30-min. or 60-min. models; controls loads to 12 amps. 110 v. ac. or dc.; actuates on-the-spot or remote audible alarms and visual signals; has self-winding spring-power movement. Operation: turning pointer to desired interval closes main switch. When time has expired, load switch opens and signal circuit closes; manual push button must be pressed to shut off signal.—*Walser Automatic Timer Corp., 420 Lexington Ave., New York 17, N. Y.*



For more information circle **342** on inquiry card.

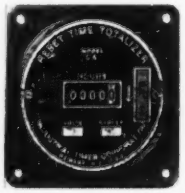
Running Time Meters

New "Series C2" running time meters are available with ranges of 10,000 or 100,000 hours, counting in 0.1- or 1-hour units; and with ranges of 10,000 or 100,000 minutes, counting in 0.1- or 1-minute units; for 115-, 220- or 440-v. operation at 60, 50 or 25 cps. Units are operated by heavy-duty self-lubricating synchronous motors; are completely enclosed to seal out moisture and dust; are housed in 3.5-in. black Bakelite cases. Also announced are open type meters available in same ranges and ratings.—*Industrial Timer Corp., 115 Edison Pl., Newark 5, N. J.*

For more information circle **343** on inquiry card.

Elapsed-time Meters

New "Model C5 Reset Time Totalizer" incorporates a reset counter that permits user to reset to zero at any time. It has a range of 10,000 hours; counts in tenths of hours; can be supplied for 115- or 220-v. operation at 60, 50 or 25 cps. "Model C5A" has a range of 100,000 hours, counts hours units. New units have heavy-duty self-lubricated synchronous motors, geared to 5-digit counters. Housing measures 2.875 in. in diameter, 3.25 in. long; steel mounting flange 3.25 x 3.25 in. Also available are open type meters ("Models C7 and C7A").—*Industrial Timer Corp., 115 Edison Ave., Newark 5, N. J.*

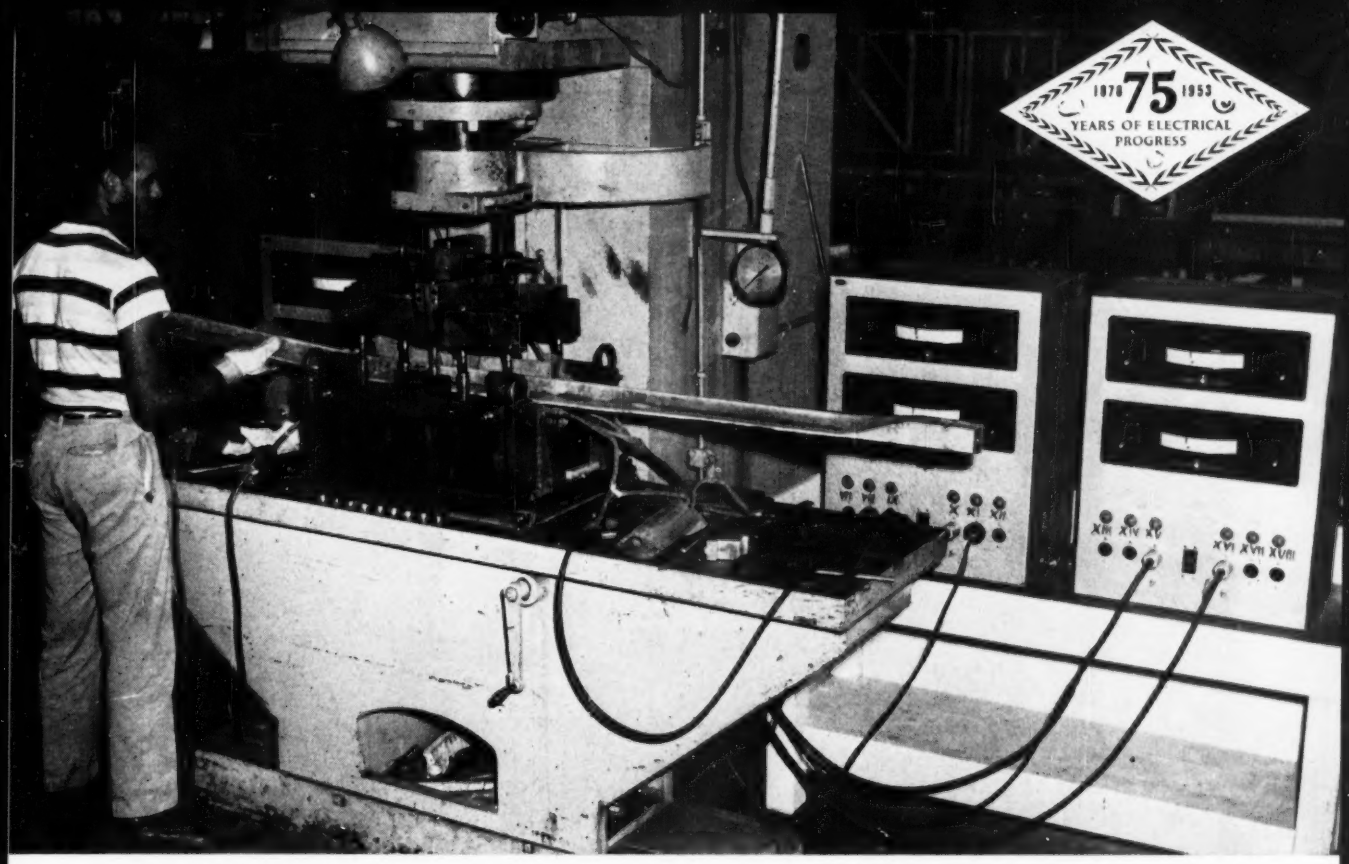


For more information circle **344** on inquiry card.

Electronic Counter

New "Model 1104 Plug-in Counter Decades" may be used directly to count events, coincidents or correlation in a run. If used with a time

Circle **57** on inquiry card. ⟶



OPERATOR REMOVES AIR-FRAME MEMBER FROM PRESS. SIX G-E PYROMETERS KEEP THE DIE TEMPERATURE CONSTANT.

G-E Pyrometers Provide Inexpensive Control For Process Die at Douglas Aircraft Co.

PLUG-IN UNIT is readily accessible for any maintenance checks. The cover is easily removed and the unit pulled out. Standard vacuum tube is shown on right end of unit.

Douglas Aircraft Company, Santa Monica, Calif. is currently using six G-E pyrometers to control an electric die which is used in a hydraulic forming press. To relieve stresses which might be set up during the forming process, the aluminum members are first heated in a furnace and then placed in the electrically heated die. The temperature of this die is kept constant by the G-E pyrometer equipment. Accurate control of the die must be maintained as each member in its finished state is worth about $2,000.

THE G-E PYROMETER is a two-position (on-off) direct-deflection millivoltmeter type. Besides being one of the least expensive types of automatic control, the General Electric pyrometer employs an extremely simple and reliable construction, thus assuring dependable operation.

STURDY CONSTRUCTION throughout makes the G-E pyrometer equipment rugged and vibration resistant. Two of the features which assure low maintenance cost are: a readily accessible plug-in control unit, and a standard vacuum tube which permits easy and low-cost replacement.

MORE INFORMATION is available from your nearest G-E apparatus sales office or write for Bulletin GEC-713, General Electric Co., Section 602-248, Schenectady, N. Y.

You can put your confidence in—

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For more information circle **57** on inquiry card.

SLIDE RULE PORTABILITY!

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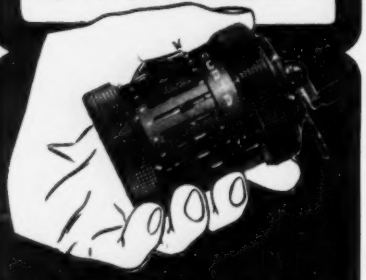

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WRITE DEPT. I-11

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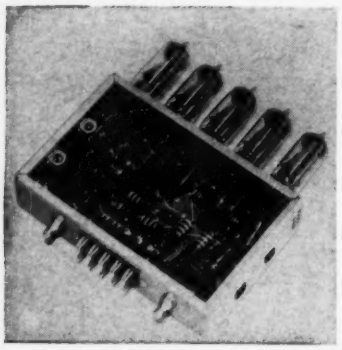
Chicago 24, Illinois

For more information circle **58** on inquiry card.

NEW INSTRUMENTS

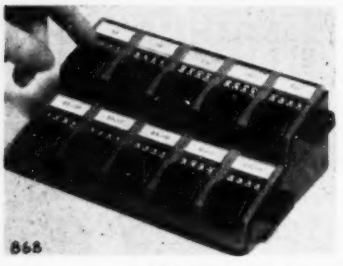


base generator, rate counts and time intervals may be determined. Among uses: counting moving production items; inventorying flat stacked objects; counting analog-to-digital converter outputs; etc. Rate, 45,000 counts per minute. Output is positive pulse, 115-v. peak amplitude, suitable for feeding other decades, indicators, mechanical counters or relays. —*Clary Multiplier Corp., San Gabriel, Calif.*

For more information circle **345** on inquiry card.

Multiple-unit Counter

New "Vary-Tally" multiple-unit reset counter facilitates quality control, stock control, laboratory analysis, etc. Arranged compactly on stands



in tiers up to 6 high and 12 wide, as many as 72 "Vary-Tally" units can be used to obtain numerical breakdowns of parts, products, etc., by specific denominations or anything countable.—*Veeder-Root Inc., Hartford 2, Conn.*

For more information circle **346** on inquiry card.

Electronic Counter

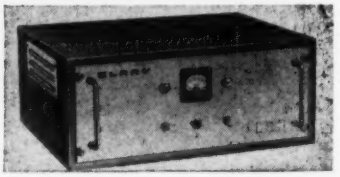
New "Model 162A Glow Transfer Counter" has maximum capacity of 1,000,000 and speed range of 0 to 5,000 counts per second. All counting,

indication, and transfer is done within cold-cathode glow transfer tubes upon which counter is based. These tubes have bright red neon glows opposite circular spacings (0-9) to show accumulated count. Two units can be run in cascade, one feeding millions into the other. A jack in rear of chassis provides for remote control connection. Instrument will accept positive or negatives pulses or sine waves of 4 to 60 volts.—*Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass.*

For more information circle **347** on inquiry card.

Pulse Counter

New "Model 1022" electronic pulse counter, for counting and totaling results from electronic computers, Geiger counters, oscillogram readers,



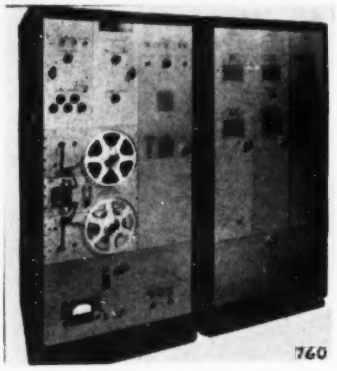
and other sources having proper characteristics, operates at speeds up to 250 pulses per second; is readily adaptable to laboratory or industrial data-processing purposes.—*Clary Multiplier Corp., San Gabriel, Calif.*

For more information circle **348** on inquiry card.

COMPUTING

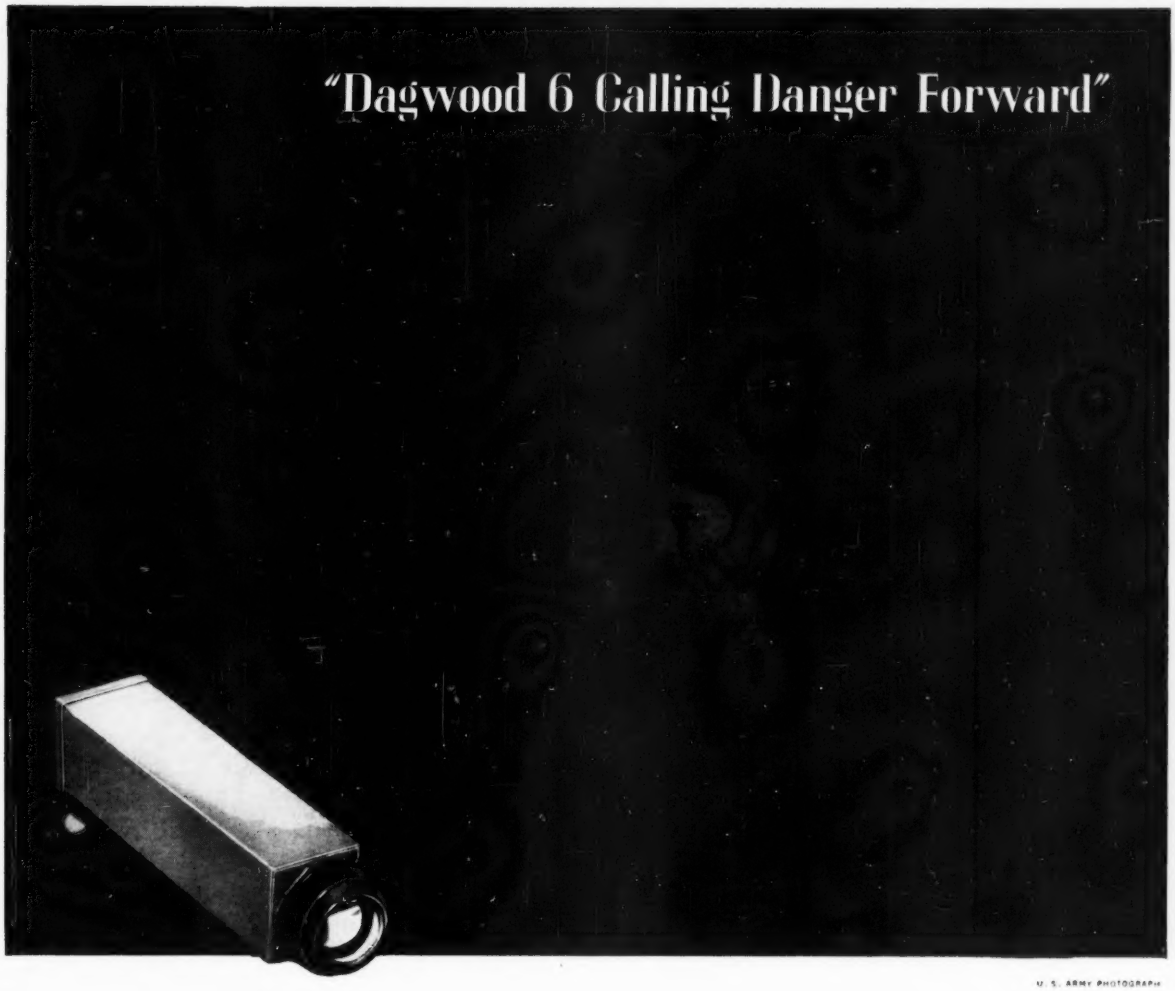
Digitizer and Memory

New multi-channel data handling system (for use in aircraft and missile testing but with industrial applications) is designed to digitize, sample, and record information obtained from Doppler-frequency effects



or pulse code modulation from each of three independent channels and to provide, through a fourth channel, recorded time marker signals as a data reference. Special decades are used to allow addition or subtraction of counts and to provide an indication of algebraic sign of total counts. "On-the-fly reading" feature obviates need of alternating measurement and sampling cycles. Key element in data reduction process is maker's new "Digital Magnetic-Tape Handler" which permits recording data from all four channels at high rates and playback at slower speeds required to accumulate information on tabulating cards or for insertion into electronic computers. Individual components or

"Dagwood 6 Calling Danger Forward"



U. S. ARMY PHOTOGRAPH

G.I. Joe now puts his calls through a new field switchboard twice the capacity and one-third the size of the one toted by his World War II counterpart.

The new "board" has a constitution that can winter in Rejkjavik, summer in Mombasa, and roll with a punch . . . just in case travel gets rough. Its retractable cords know when to come in out of the rain and goo.

Among the many essential parts of this instrument there is one named simply "SIGNAL, switchboard." It is a luminous-painted signal, operated by an electro-magnet, which "drops" into view when a line is calling. There's one "drop" for each telephone cord circuit; each drop is enclosed in a square housing made from Superior Hard Drawn Carbon Steel AISI C1008—.6815" I.D. Square, .020" wall, 2.656" long. Tolerances are close—±.005" on the length and +.007",—.000" on width.

Mr. Lloyd Bender, Vice President of The North Electric Manufacturing Company, makers of the switchboard, says of Superior, "Your performance has been excellent—in workmanship, quality of material and delivery."

Are you looking for a good small-tubing source—one that gives you the widest choice of tubing analyses available in America today, one that can supply you with one or one-million feet, one known for its uniformly high quality, and its interest in you and your tube problems? Try Superior. Superior Tube Company, 1968 Germantown Ave., Norristown, Pa.

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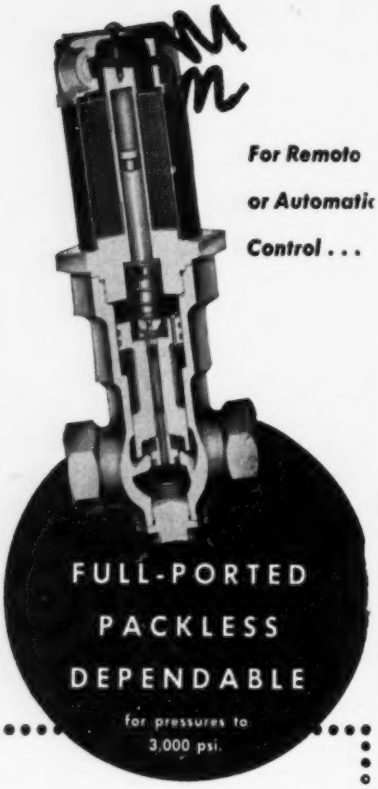
For more information circle **59** on inquiry card.



Atkomatic Solenoid Electric Valves are available in sizes from ¼ inch to 3 inches, and for pressures to 3,000 psi. Adjustable timing on the closing stroke is available on all valves up to pressures of 300 psi.

Designed with only three moving parts and no external linkage, wear and maintenance are greatly reduced. Availability for normally opened or normally closed operation makes it possible for the valve to fail safe in the event of power failure.

Atkomatic Solenoid Electric Valves are made with standard coils of paper insulation, vacuum impregnated and baked for resistance to moisture, or glass-insulated coils for higher temperatures.

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For more information circle **60** on inquiry card.

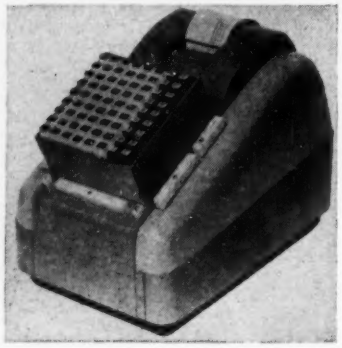
NEW INSTRUMENTS

complete systems are now available to provide sampling rates to 100 per second, and these may be combined with existing or proposed methods employing punched cards, direct data printers, or magnetic tape recorders. —*Potter Instrument Co., Inc., Great Neck, N. Y.*

For more information circle **349** on inquiry card.

Digital Read-out Printer

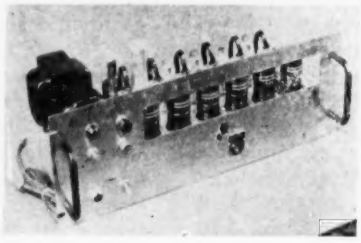
New "Digital Printing Read-out Machine" prints data in electrical pulse form. Three types available: "Model 190," used when accumulation-and-storage of numerical data is not necessary; "Model 191," used when numerical data are accumulated in machine and accumulated amount is periodically printed; and "Model 197," used where plus and minus numerical data are entered into machine and accumulated amount periodically printed in algebraic values. Latter two models may be manually operated.—*Clary Multiplier Corp., San Gabriel, Calif.*



For more information circle **350** on inquiry card.

Decade Scaler

New high-speed six-digit decade-scaler is for use in telecommunication and in computers for frequency and nuclear measurements. Including power supply and appropriate control circuits, it has a maximum cyclic rate of 30,000 events per second, minimum resolving time of 25 microseconds, and a total registration of 999,999. Philips direct-indicating E1T tubes are used. Input circuit uses a Schmitt trigger, with adjustable sensitivity, responds to changes in input level, thus is not limited to any specific input wave shape. Sine waves of 1 volt rms. can be counted at speeds of 5 to 30,000 per second. Pulses at any rate below 30,000 per second are accepted. A special terminal permits signals which vary at slow d-c. rates to operate counter. Standard rack mounting. Dust cover included. Operation from 95-130-v.ac. line..—*Research & Control Instruments Div., North American Philips Co., Inc., 750 S. Fulton Ave., Mount Vernon, N. Y.*



For more information circle **351** on inquiry card.

Analog Computer

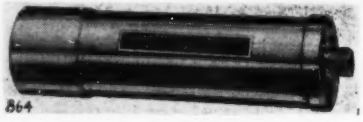
New "Complex Plane Analyzer," for design of networks and feedback control systems, multiplies and divides vectors plotted on complex frequency plane. Gain and phase shift results are computed simultaneously and appear directly on indicator. Frequency response, transient behavior and root locus solutions are found for both open- and closed loop systems. Responses to impulse, step, exponential and complex driving functions can be solved. Accuracy is better than 1 percent. "CPA" has an input device which operates like an electric tape measure and introduces vector angle and log-magnitude dimensions (in d-c. voltage form) into computing circuit. Circuit stores and sums input voltages in two capacitor banks. Total angle voltage, read on indicator, represents system phase shift. Total log-magnitude voltage represents system gain, or attenuation. Up to ten vectors can be multiplied at once. Zero-suppression technique makes possible rapid and precise measuring of angles from −3600 deg. to 3600 deg. and magnitudes from one ten-billionth to ten billion. Analyzer consists of vector measuring input unit, vector multiplying circuit, set of batteries, and instruction booklet.—*Technology Instrument Corp., Acton, Mass.*

For more information circle **352** on inquiry card.

NUCLEONICS

Scintillation Counter

New "SC-33 Miniature Basic Unit" is 6.5 in. long, light-weight for portable equipment, with threaded end for rapid attachment of accessories.



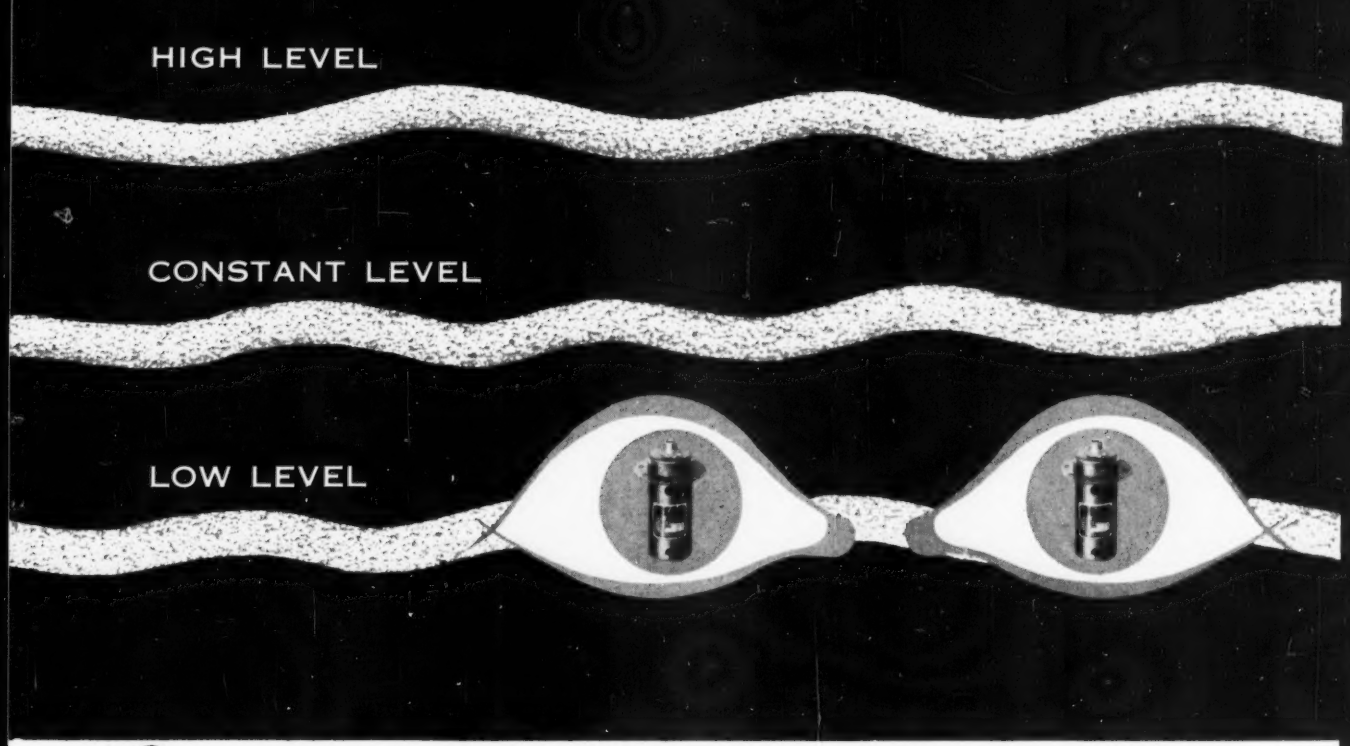
Phosphors are used in conjunction with a RCA 6199 phototube pressed against plexiglass crystal mounting, with DC-200 silicone between: optical contact fully equivalent to a cemented joint. Alpha, beta, and gamma phosphors up to 1.5 in. diameter are obtainable.—*Nuclear Research and Development, Inc., 6425 Etzel Ave., St. Louis 14, Mo.*

For more information circle **353** on inquiry card.

Counting Ratemeter

"Model RAC-11 Ratemeter-Alarm-Control" has built-in circuits for alarm, control and recording; is suitable for laboratory monitoring, half-

Circle **61** on inquiry card. ⟶



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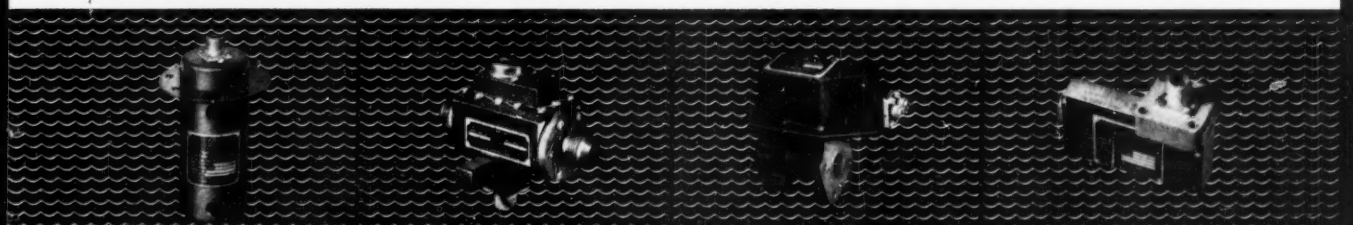

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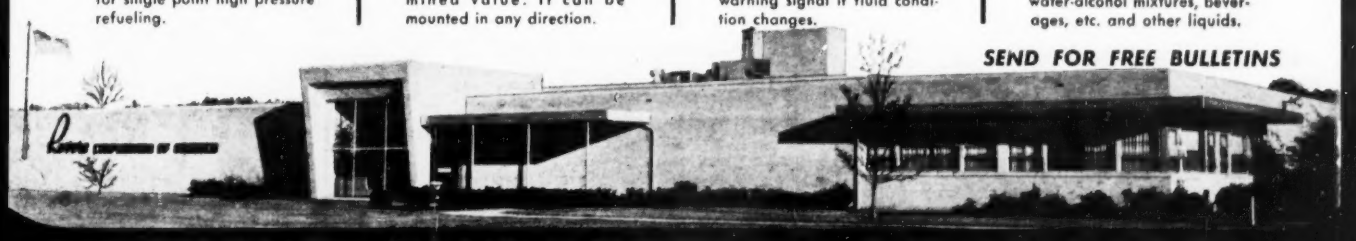

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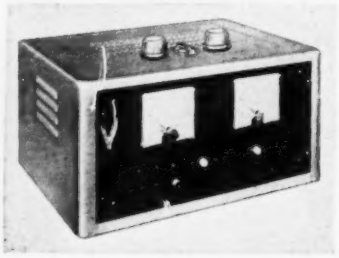
For more information circle **62** on inquiry card.

NEW INSTRUMENTS

life studies, process control, etc.; can be operated by a Geiger-Mueller tube connected directly to input or by any device producing similar pulses. Ranges: 0-2000, 0-10,000, 0-20,000 (others available). Panel lights indicate range instrument is operating

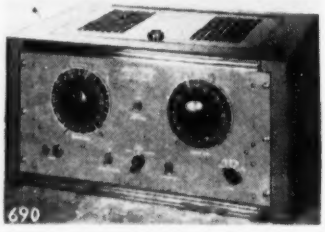


on. Stability: output rate changes less than 0.5 percent when line voltage varies from 100 to 130 v. (both filament and plate supply are regulated); no drift due to tube or component aging. Instrument shifts ranges up or down automatically; range can be shifted manually for operation on a particular range. Alarm is normally plugged into control circuit; amber light and 15-second bell actuated when middle range is reached; red light and continuous bell activated when high range is reached. Recorder can be plugged in directly. — *Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis* 18, *Ind.*

For more information circle **354** on inquiry card.

Pulse-height Analyzer

New "Model 115 Single-channel Pulse-height Analyzer," said to be the most efficient and most economical instrument for studies of amplitude



distribution of electric pulses between 0 and 100 volts, incorporates its own linear amplifier, pulse generator, and coincidence and anticoincidence circuits; may be used as either integral or differential analyzer.—*Radiation Instrument Development Lab., 2337 W. 67th St., Chicago* 36, *Ill.*

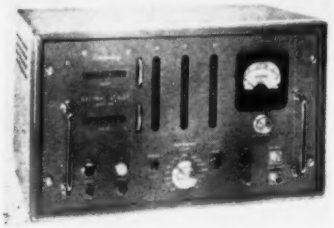
For more information circle **355** on inquiry card.

Film Badge Service

New type of film badge service, designed specifically for use when handling gamma radiation sources, is low-cost, with minimal bookkeeping and mailing: film badges in lots of 20, 50, 100 or 500 for use only as user needs them.—*Technical Operations Inc., 6 Schouler Court, Arlington, Mass.*

Decimal Scaler

New "Model 2001 Decimal Scaler" (replacing "Model 2000") employs an electronic scale of 1000. Its circuitry provides for a large number

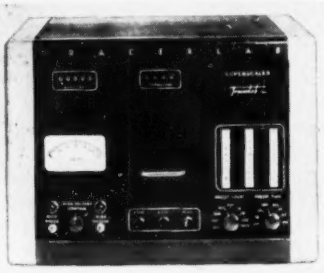


of preset counts and scaling factors for operating external registers or other devices. A drum-type time clock on front panel beneath mechanical register simplifies reading and recording information.—*Berkeley Scientific, Div. of Beckman Instruments, Inc., Richmond, Calif.*

For more information circle **356** on inquiry card.

Combination Scaler, Ratemeter, etc.

New "Superscaler" features provision for plug-in units which effectively convert it into a variety of specialized instruments: each addi-

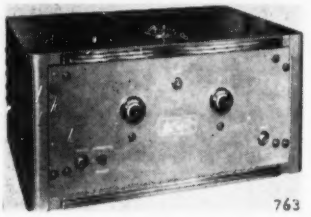


tional unit plugs directly into front panel. Now available are a pulse amplifier, a ratemeter, a discriminator and a blank chassis which make it possible for users to construct their own special circuits to precede or follow scaler.—*Tracerlab Inc.,* 130 *High St., Boston* 10, *Mass.*

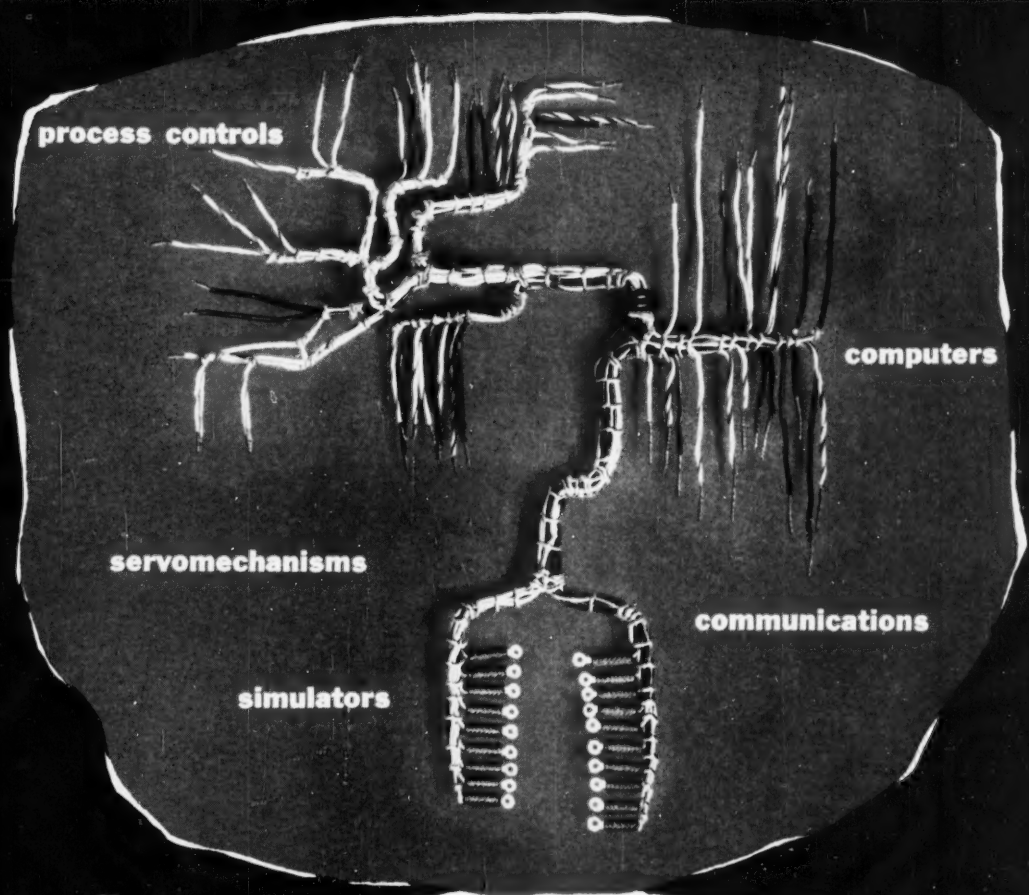
For more information circle **357** on inquiry card.

Differential Analyzer

New "Oak Ridge Single Channel Differential Analyzer, RCL Mark 15 Model 2204," (ORNL-Q-1192; Model



5), has an expander amplifier using Type 404A pentodes. (This tube has a gain-band-width product higher than any other conventional receiving tube.) Cathode follower output of



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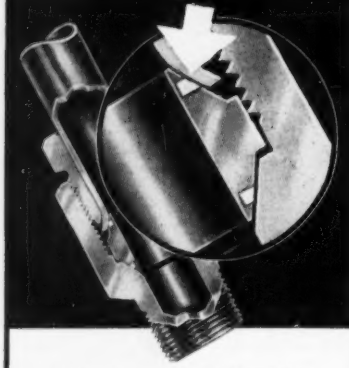

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NEW INSTRUMENTS

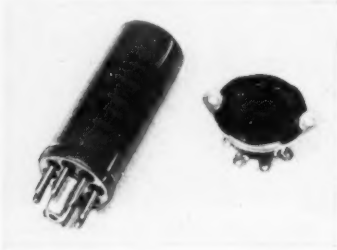
feedback amplifier supplies a portion of input signal, amplified by a factor of ten to upper level discriminator, and lower level discriminator. Outputs of discriminator circuits (also 404A pentodes) feed into memory and anti-coincidence circuits. Use of IN-38A crystal diode prevents plate voltage of first amplifier 404A from falling more than 5 volts below its quiescent value; limited potential swing allows this plate to recover rapidly after a large signal. Also, an abrupt and fast rise of output pulse is assured through use of an "amplified-diode" break-away circuit.—*Radiation Counter Laboratories, Inc., Skokie, Ill.*

For more information circle **358** on inquiry card.

ELECTRICAL INSTRUMENTS

Bridge Comparator

New hermetically-sealed, packaged full-wave bridge comparator, for phase and amplitude comparison, can be used as a modulator, rectifier, switch or chopper. It consists of two complete bridges with appropriate switching resistors; has a frequency range of 0 to 5000 cps., conversion efficiency of 85 percent, dynamic range of 46 db with fixed-reference amplitude and 60 db with variable reference, linearity (over this range) 1 percent of full scale: Maximum signal voltage 60 v. rms.; maximum reference voltage 130 v. rms.; d-c. output plus or minus 50 volts when used as a comparator.—*Sanders Associates, Inc., Nashua, New Hampshire.*



For more information circle **359** on inquiry card.

Harmonic-distortion Meter

"No. 1410 Harmonic Distortion Meter," for carrier frequency ranges of 20,000 cps. to 1 Mc., has harmonic-distortion range of 0.1-30 percent, has a maximum input voltage of 1000 volts; is self-contained and a-c. operated; weighs 45 lbs.—*Freed Transformer Co., 1718 Weirfield St., Brooklyn 27, N. Y.*

For more information circle **360** on inquiry card.

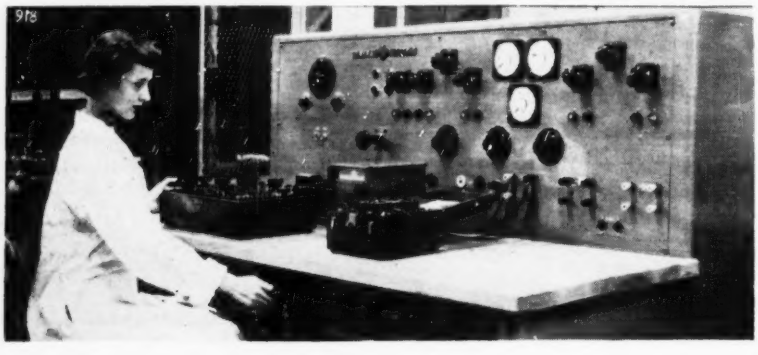
Capacitance Indicator

New "Model C102 Capaciprobe" makes it possible to measure total capacitance at any point within a circuit with that circuit operating under its normal d-c. conditions. No pre-zeroing required: place probe tip

Electrical Instrument Standardization Equipment

New instrument standardization console, said to be "the most complete single facility ever built for general instrument calibration," supplies low-distortion regulated power in a-f. frequency range of 50-3000 cps. A-c. and d-c. voltage and current supplies are provided on conventional bus facilities up to 150 amps., 750 volts. Basic design principle is the use of "transfer standards" for standardization of a-c. instruments. Console comprises two sections: back or cabinet section contains most sub-assemblies; front or table section serves primarily as a work area, has non-magnetic work surface. A regulator on console provides a stable voltage source to all components affecting calibration; is not energized until main switch is closed. D-c. potential supply consists of a rectifier unit and a filter unit. A conventional full-wave rectifier circuit uses a three-stage filter so that 120-cps. ripple is minimized. For low-voltage operation below stability limit of d-c. supply, a dry-type 6-volt battery can be used as a source of power. Console power requirement: 115 v., 60 cps., 30 amps.—*General Electric Co., Schenectady 5, N. Y.*

For more information circle **361** on inquiry card.



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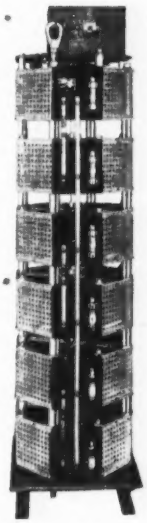

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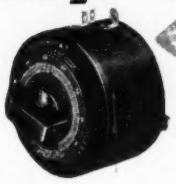

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TYPE 0-1126

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400/800 CYCLE MIDGET FRAME SIZE

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Please send literature on POWERSTAT variable transformers.

NAME _____

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For more information circle **65** on inquiry card.

HERE IS THE SOLUTION

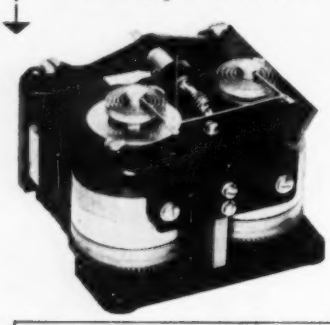
to many metering and positioning problems requiring extreme sensitivity *and* extreme durability.

Texas Instruments originally developed this sensitive, smooth, linear and long-lived **magnetic fluid clutch meter/positioner** to solve a 30° bi-directional recording problem in some airborne military gear. Simply and durably built, it far outlasts anything similar we've ever seen (over 3000 hours continuous duty at rated load).

In essence, it consists of two TI-developed magnetic fluid clutches (weighing .46 lb each) working in opposition. Input current of 100 microamps causes a 6° output shaft deflection with from 10 to 500 microamps being measurable. General data is appended.

If *you* are being perplexed by a metering/positioning problem demanding a rugged — yet sensitive and accurate — movement, just drop us a line and we'll be glad to answer your questions in detail.

TI magnetic fluid clutch meter/positioner



SPECIFICATIONS

Meter/Positioner Movement

Sensitivity	6° per 100 microamps
Accuracy	±5%
Life	3000 hr @ rated load
Frequency Response	Flat to 5 cps, as applied
Deflection	30° either side of zero
Min. Input Signal	10 microamps
Max. Input Signal	500 microamps
Ambient Temp. Range	−40 to +75° C
Coil Impedance	15,000 Ω, 450 henries

* following data taken w/o springs

Output Torque	0.125 oz-in./100 microamps
Maximum Output Torque	5-25 oz-in. at 4 millia nps

TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVE DALLAS 9, TEXAS

For more information circle **66** on inquiry card.

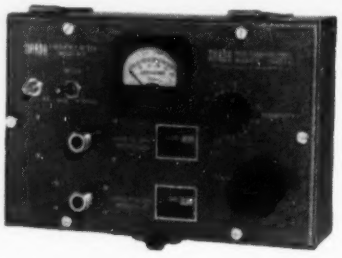
NEW INSTRUMENTS

to node in question and turn direct-reading dial until tuning-eye closes. Range 0-110 uuf.; accuracy 1 percent.—*Electronics Production Service Co., 871 Washington St., Canton, Mass.*

For more information circle **362** on inquiry card.

Frequency Meter

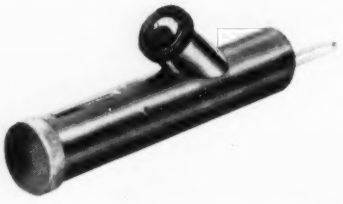
New "Model 802" frequency meter measures frequencies from 2400 to 10,200 Mc. to an accuracy of 0.2 percent. A transmission indication is obtained on a built-in 50-ua. microammeter. A reactive indication is obtained by using an external tee section. Resonant elements consist of two high-Q coaxial cavities tuned by a micrometer head.—*Nassau Research & Development Associates, Inc., 66 Main St., Mineola, N. Y.*



For more information circle **363** on inquiry card.

UHF Wavemeter

New "Model U-3 UHF Wavemeter," designed for UHF-TV band, covers range from 400 to 1000 Mc.; provides a considerable overlap in frequency spectrum from nominal 470-890 band allocated for this service. Coupling to wavemeter tuning element is facilitated by use of an external coupling cap so designed as to permit easy access to portion of circuit under examination. Absorption circuit consists of a high-Q resonant cavity tuned by means of a slug-type split stator capacitor, providing a sharp indication of resonance. There being no sliding contacts, unit is unaffected by moisture, oxidation, or wear.—*Linear Equipment Labs., Brightwater Place, Massapequa, L. I., N. Y.*



For more information circle **364** on inquiry card.

Laboratory Voltmeter

New "Model R-1 VTVM" is said to embody substantial improvements in stability, accuracy, ease of operation, and maintenance. Circuit refinement and use of maker's new wire-wound resistors have decreased drift in dc. millivoltmeter and the d-c. amplifier to less than three millivolts per hour, and make possible use of standard, non-critical tubes. "Model R-1" is primarily intended for precise measurement of d-c. potentials, but the following auxiliary functions have been included in its design: distended d-c. voltage ranges; d-c. millivolt ranges; a-c. volt and millivolt ranges; self-contained standard cell; ohms and distended ohms ranges; d-c. amplifier.—*Southwestern Industrial Electronics Co., P. O. Box 13058, Houston 19, Texas.*

For more information circle **365** on inquiry card.

Sweep Generator

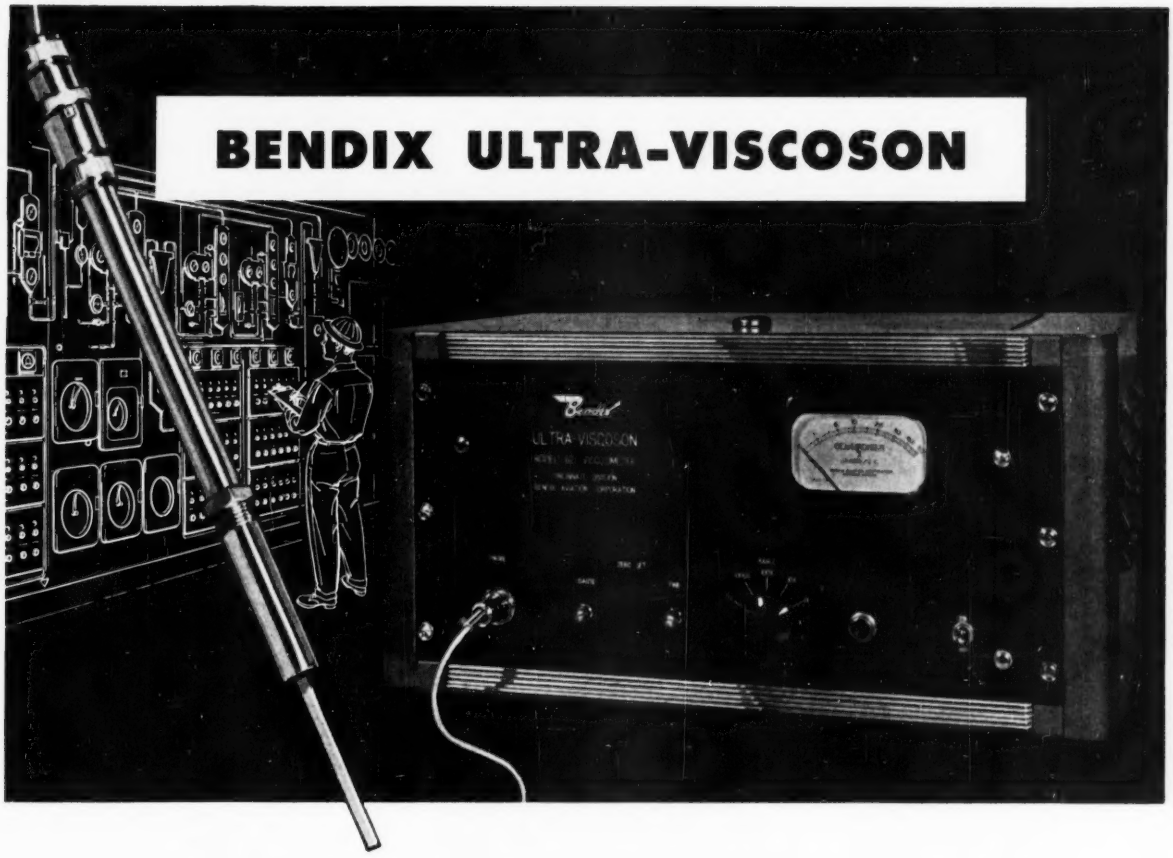
New UHF sweep generator weighs 20 lbs.; measures 10x12x9 in.; covers range of 420-930 Mc. and has a sweep width of 0-50 Mc.; is available in two models: (1) "Model S" sweep oscillator only. (2) "Model SM" sweep oscillator and marker oscillator. Each oscillator is individually calibrated; accuracy 0.5 percent. Fixed absorption type markers are available; other frequency coverage up to 1100 Mc. available on special request.—*Telonic Industries, 444 South Rural St., Indianapolis, Indiana.*

For more information circle **366** on inquiry card.

Microwave Oscillator

New "Model 803 Ultra-Stable Microwave Oscillator" features an S-band oscillator stabilizer for long-term drift of one part in 10^5, a frequency-calibrated dial, means for modulation,

BENDIX ULTRA-VISCOSON



measures, records and controls viscosity instantly, continuously, automatically!

This unique electronic instrument—the Bendix Ultra-Viscoson—provides *instant*, *continuous* and *automatic* viscosity measurement of hundreds of fluid materials in any stage of processing. All you do to get an accurate viscosity check is look at the dial. And all you do to install it is insert the small, rugged probe—by means of threaded connections—in a pipeline, kettle, pressure vessel, fractionating tower or tank.

In addition to indicating viscosity, the Bendix Ultra-Viscoson can be connected directly to any standard recorder or recorder-controller to automatically record and control viscosity in continuous processes.

You'll realize substantial savings, too, with a Bendix Ultra-Viscoson on the job. It completely eliminates costly work stoppage, sample taking, lengthy laboratory analyses and human error. Find out how you can improve your operation with a Bendix Ultra-Viscoson. Write today for complete information.

Simple ... Flexible ... Reliable!

No moving parts • Hermetically sealed probe • Operates in temperatures up to 650°F. and pressures of 1000 p.s.i. (special units available for higher pressures) • Measures in milliseconds • Remote operation • Permanently installed probe • Easily combined with remote recorder and automatic controls • Multi-probe and automatic temperature compensating systems available

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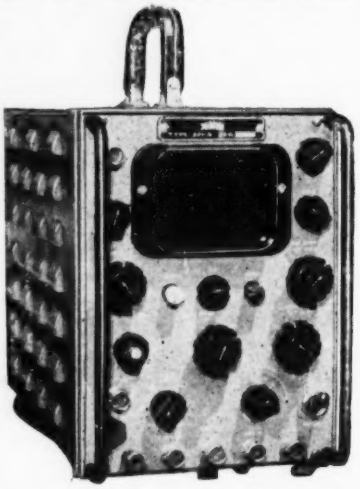
For more information circle **67** on inquiry card.

and a self-contained power supply. Main elements are a klystron oscillator, a stabilizing monitor loop which consists of a calibrated dual-mode reference cavity and a feedback amplifier. Frequency coverage is 2700-2950 Mc. Pulse modulation is possible when stabilization is removed, and 25 percent modulation when stabilized. Attenuator provides 100-db range of control. Power output is 15 milliwatts from a Type N output connector. Cabinet dimensions 10.5x 19x14.6 in.; rack mounting; total weight 100 lbs.—*Laboratory for Electronics, Inc., 75 Pitts St., Boston 14, Mass.*

For more information circle **367** on inquiry card.

Miniature Wide-band CRO

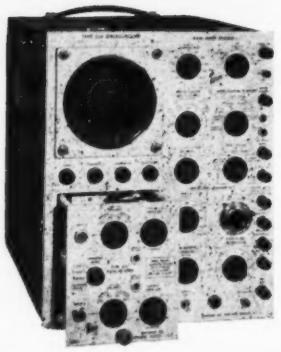
New "Type 301-A" wide-band quantitative oscilloscope is 9.12 in. high x 6.5 in. wide x 16.62 in. deep, weighs 20 lbs. (Size and weight include protective front panel-cover and three accessory probes and cables.) Bandwidth extends from 10 cps. to 4 Mc. (20 percent down). "Type 301-A" is said to be ideal for field maintenance of computers, airborne instruments, etc. Primary power requirement is 115 volts, 50 to 1000 cps., permitting operation from almost any field power source. —*Technical Sales Dep't, Allen B. Du Mont Labs., Inc., 760 Bloomfield Ave., Clifton, N. J.*



For more information circle **368** on inquiry card.

Cathode-ray Oscilloscope

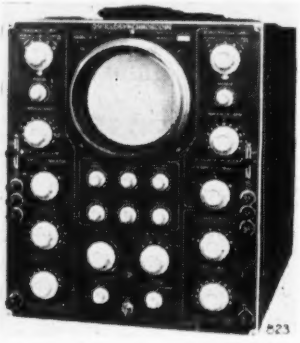
New "Type 535" provides an exceptionally wide range of facilities in a single oscilloscope. Plug-in preamplifiers, new accurate sweep delay circuit, wide time-base range, and high accelerating potential. New sweep circuit provides 24 calibrated sweeps from 0.1 usec/cm. to 5 sec/cm. with 5x magnification on all ranges, and continuously-variable uncalibrated sweeps from 0.1 usec/cm. to 10 sec/cm. Automatic main sweep lockout with controllable reset permits delay of start of main sweep from 10 usec to 20,000 usec. Trigger selector permits automatic triggering or amplitude selection. Balanced delay network provides 0.25 usec signal delay. New "Type 51P2" metallized 5-in. CRT. Six output waveforms available at front panel. Three different plug-in preamplifiers available: "Type 53C Dual-Trace Unit", "Type 53D Differential High-Gain DC Unit"; and "Type 53A Wide-Band DC Unit."—*Tektronix, Inc., P. O. Box 831, Portland 7, Oregon.*



For more information circle **369** on inquiry card.

Oscillosynchroscope

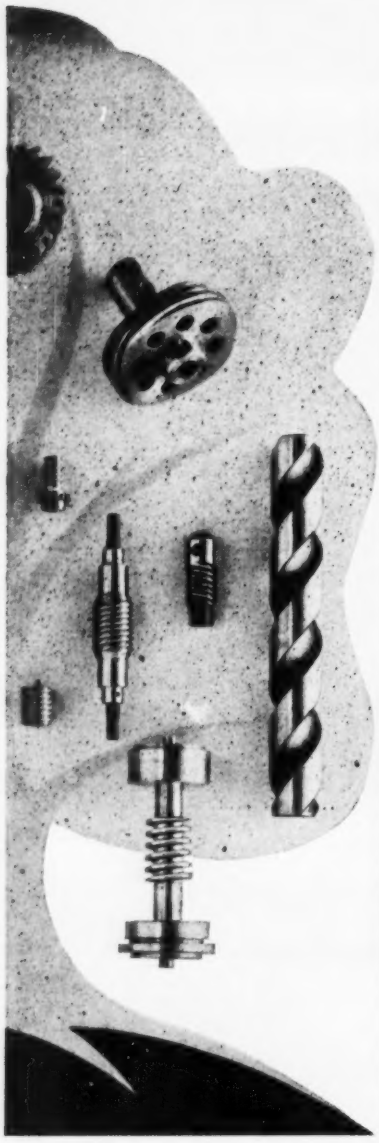
New "Model OA-16 Oscillosynchroscope" features a calibrated buck-out voltage which allows balancing out of d-c. levels accurately to 10 percent so that small superimposed a-c. signals can be expanded for more minute inspection of both signal and small changes in d-c. level: possible 40:1 expansion of signal over that observable using conventional d-c. methods. Also featured are vertical and horizontal amplifier bandwidths from d.c. to 5 Mc. and 1 Mc., and sensitivities of 50 mv. peak-to-peak per inch and 120 mv. peak-to-peak per inch, respectively. Triggered or recurrent sweeps from 0.4 usec./cm. to 10 seconds total sweep time. Video delay line permits observation of rising wavefronts of pulses.—*Browning Laboratories, Inc., 750 Main Street, Wincheater, Mass.*



For more information circle **370** on inquiry card.

Oscillosynchroscope

New "Model OL-23 Oscillosynchroscope" features 4000 volts accelerating potential, vertical amplifier bandwidth flat from 5 cps. to 10 Mc. with a sensitivity of 0.15 volts peak-to-peak per inch, and triggered or



For more information circle **68** on inquiry card.

PYROTRON
by BAILEY...

Your best buy for Precision Temperature Measurements In the -300F to 1200F Range

Check These Exclusive Bailey Advantages of Resistance Thermometer Operation

✓ Resistance thermometer operation over a complete range from —300F to 1200F has been made possible by Bailey's development of a low-cost platinum resistance element.

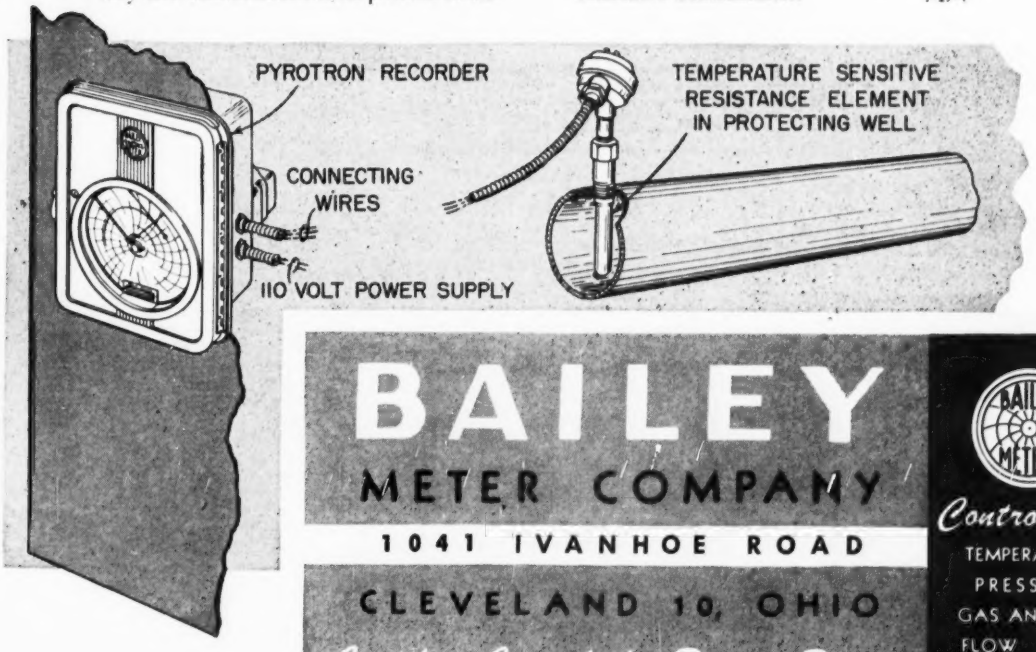
✓ Resistance thermometer operation requires no standard cell, dry battery and cold junction compensator. Uses 115 volt a-c source. Strong signal and high precision of resistance element as compared to thermocouple makes possible the use of narrow range spans.

✓ The Bailey Pyrotron is calibrated at the factory and *remains* accurate; no periodic re-calibrations required. Since all elements are matched it is not necessary to calibrate each recorder to its element.

✓ Recorder is sensitive to 1/10 of 1% of range span.

✓ Ordinary copper lead wires permit remote location of recorder with respect to the temperature sensing element.

✓ For complete information, write for bulletin 230-C on the Bailey Pyrotron Electronic Resistance Thermometer. P-27-1



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BAILEY METERS

Controls for

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For more information circle 69 on inquiry card

PALMER

MERCURY ACTUATED

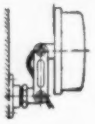
Dial Thermometers now in three types to suit any requirements

PATENTED

Full 4½" dial face. Stem can be placed at any angle and case can be rotated to any readable position.

1 **Rigid Stem Dial Thermometer** tapered bulb, interchangeable with standard industrial thermometer separable socket. (As illustrated above.)

2 **Wall Mounted Dial Thermometer** with flexible connecting armor. Case adjustable to easy reading position.



3 **Flush Mounted Dial Thermometer** for panel mounting with flexible connecting armor.

All three types have a full 4½" dial face.

for accuracy: Mercury actuated . . . Fully Compensated by Invar Compensaton. Guaranteed Accurate 1 scale division.

for angularity: Can be adjusted to most readable position at any angle desired.

for readability: Bold Black Numbers . . . 11" of scale Reading Dial face can always be placed in easiest readable position.

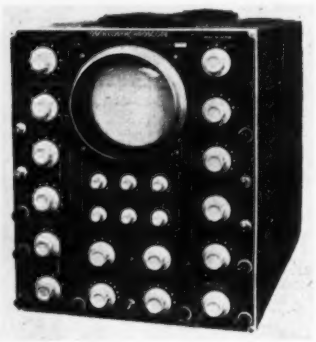
for interchangeability: Always specify "PALMER" Separable sockets as they are interchangeable for Dial or Industrial type Thermometers.

Send for Bulletin 51-129 for details on the New Palmer Dial Thermometer.

PALMER
THERMOMETERS, INC.
Norwood Ave., Cincinnati 12, Ohio
Mfrs. of Industrial Laboratory Recording and Dial Thermometers

For more information circle **70** on inquiry card.

NEW INSTRUMENTS



recurrent sweeps from 0.1 usec./cm. to 0.011 sec./cm. Video delay line permits observation of rising wavefront of pulses.—*Browning Laboratories, Inc., 750 Main St., Winchester, Mass.*

For more information circle **371** on inquiry card.

Audio Signal Generator

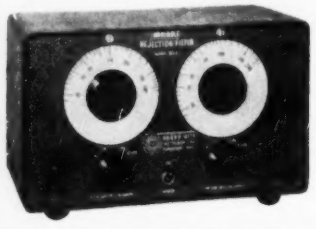
New "WA-44A" audio signal generator designed for service and laboratory applications and for use in "hi-fi" sound field has frequency range of 11 cps. to 100 kc. Sinoidal output has less than 2 percent total harmonic distortion from 30 to 15000 cps. and maximum hum level of 0.1 percent of rated output. Output voltage varies less than 1 db over entire frequency range. Frequency stability and calibration accuracy permit use in measuring frequency of rotating and vibrating bodies, measuring resonance of loudspeakers and enclosures, and determining resonant frequency of *LC* networks. Dimensions, 7 x 10.5 x 6 in.; weight, 10 lbs.—*Tube Dep't, RCA Victor Div., Radio Corp. of America, Camden, N. J.*

For more information circle **372** on inquiry card.

ELECTRICAL-INSTRUMENT ACCESSORIES

Variable Rejection Filter

New "Model 360-A" adjustable rejection filter provides either a rejection band in which gain falls at rate of 24 db/octave or a sharp single-frequency null. A peaking factor



is used to reduce attenuation at cut-off frequencies. Both high and low cut-off frequencies are independently adjustable from 20 cps. to 200 kc. Rejection band width is thus continuously variable up to maximum width covering entire range from 20 cps. to 200 kc.; sharp null may be obtained at any frequency from 100 cps. to 50 kc.—*Krohn-Hite Instrument Co., 580 Massachusetts Ave., Cambridge 39, Mass.*

For more information circle **373** on inquiry card.

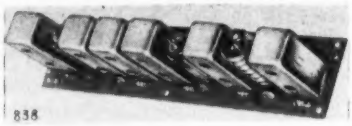
Oscilloscope Tubes

New "5ABP1, 5ABP7, and 5ABP-11" 5-inch flat-face cathode-ray tubes utilize electrostatic focus, electrostatic deflection, and post-deflection acceleration. They differ from one another only in spectral-energy emission and persistence characteristics of their respective phosphors P1, P7, and P11. Vertical-deflection electrode-pair is especially suited for operation from wide-band amplifiers: exceptionally high sensitivity making up for low-signal output of such amplifiers, and low capacitance providing type of load into which such amplifiers work best.—*Tube Dep't, Radio Corp. of America, Harrison, N. J.*

For more information circle **374** on inquiry card.

I-f. Amplifier

New "207E1" is an assembled and aligned 40-Mc. i-f. amplifier complete with tubes, designed primarily for use in TV receivers. It employs print-



ed-circuit i-f. transformers, coils, and traps arranged in tandem with three 6CB6 amplifier tubes and a Type 1N64 crystal diode. Tuning adjustments are made by means of aluminum screw disks accessible from one side of cans.—*Tube Dep't, Radio Corp., of America, Harrison, N. J.*

For more information circle **375** on inquiry card.

Servo Lead Networks

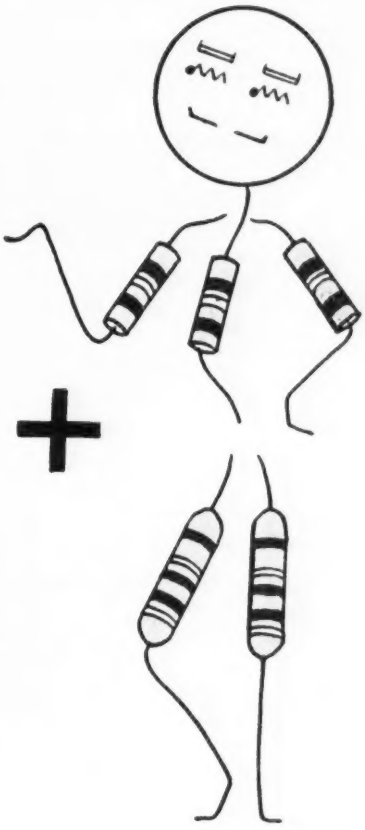
New "Series 410 Lead Networks" *RC* filters are for use as d-c. rate or derivative circuits in control amplifiers. Unlike standard *RC* lead circuit, response decreases beyond control frequency region, with a peak of attenuation at one frequency: useful following 60- or 400-cycle demodulators, or any other d-c. control signal with unwanted h-f. components. New networks are cast in plastic for sealing and small size, are offered in a variety of standard cutoff frequencies and impedances.—*White Instrument Labs., 203 Riverside Drive, Austin 4, Texas*

For more information circle **376** on inquiry card.

Pulse-forming Network

New "Model H-850" universal pulse-forming network, for laboratory use in radar research and development, has unique construction which makes it possible to obtain five most-needed pulse lengths—0.25, 0.5, 1, 2, and 3 usec.—with no distortion of pulse shape. Flat portion of pulse form is retained at all pulse lengths through maker's method of multiple

The PERFECT Wedding



TYPE 2003 FREQUENCY STANDARD

The Type 2003 contains, in addition to the tuning fork, all circuit components which are selected or critical.—The tube and remaining components — three resistors and two .01 capacitors — are external and can be laid out and integrated with your equipment.

TUNING FORK STANDARD, hermetically sealed.
SIZE — 4½ inches long. 1½ inches diameter.
SIMPLE EXTERNAL CIRCUIT, 1 tube, 3 resistors, 2 capacitors.
TUBE — Choice of 12AT7, 6201, 5751, 6BF7, 6BG7 or 6021.
POWER REQUIRED, 75 to 300 V at 1 to 5 m.a. — 6.3 V at 300 or 350 m.a.
AVAILABLE — in 400 or 500 cycles
ACCURACY guaranteed to .002%, 15° to 35° C.

Write for descriptive literature, specifying Type 2003.

Also TYPE 2007
(4½" x 1½")
COMPLETELY SELF-CONTAINED INCLUDING VACUUM TUBE

Manufacturer of high precision frequency and timing instruments controlled by tuning fork oscillators.

American Time Products, Inc.

580 Fifth Avenue **New York 36, N. Y.**

OPERATING UNDER PATENTS OF THE WESTERN ELECTRIC COMPANY

For more information circle **71** on inquiry card.

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ADVANCE RELAYS

for precise circuitry

There are many reasons why Industry specifies ADVANCE RELAYS: They meet or surpass Military and Civilian requirements—many types have AN approval—many are hermetically sealed—all are lightweight—small—rugged—compact—and all are precision-built for efficient, trouble-free, long life performance.

If you have relay problems involving contact loads, coil resistances, close differential, timing features, input sources, critical environment or any particular requirements involving unusual or accurate circuit behavior, ADVANCE can supply the relay.

A complete line of relays for radar, radio, electronic and electrical equipment applications.

Write for new, descriptive Catalog containing detailed information about ADVANCE Relays and facilities.

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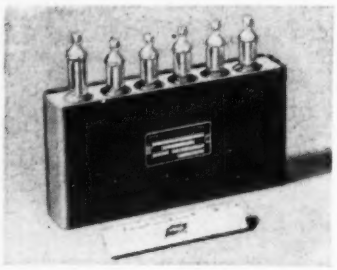
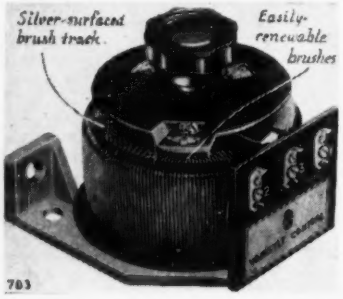


switching. New network is designed for operation with a 50-ohm impedance load. Peak voltage rating is 13 kv. regardless of pulse length used.—*Sprague Electric Co., 199 Marshall St., North Adams, Mass.*

For more information circle **377** on inquiry card.

Adjustable Autotransformer

New low-cost 2000-watt model of "Varistat" continuously-adjustable autotransformer is mounted on a



light cast alloy base; can be left at any setting indefinitely without damage. Operating torque, 30 to 60 in.-oz. Interlocking types and remote-control motor-operated units are available.—*Ward Leonard Electric Co., Mount Vernon, N. Y.*

For more information circle **378** on inquiry card.

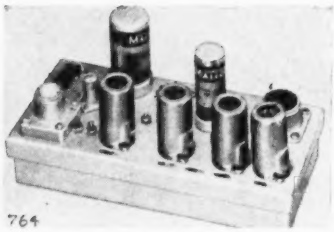
Full-wave Vacuum Rectifier

New "RCA-5690" is a "Special Red" vacuum rectifier tube for industrial and aircraft applications. It has two separate diode units of indirectly-heated-cathode type; is conservatively rated to withstand maximum peak inverse plate voltage of 1120 v., maximum peak plate current per plate of 375 ma., and maximum dc. output current per plate of 75 ma.; has minimum life of 10,000 hours when operated within maximum ratings; will withstand continuous vibration of 2.5 *g* at approx. 25 cps. for hundreds of hours, and impact shocks of 500 *g* for short periods, at maximum rated voltage.—*Tube Dep't, Radio Corp. of America, Harrison, N. J.*

For more information circle **379** on inquiry card.

Preamplifier

New "Oak Ridge A1C Preamplifier" (ORNL Specs. Q-1302 & Q-1326), latest modification of "Bell-Jordan A1A Preamplifier," has features of "A1A" plus: (1) increased output signal range; (2) input circuitry arranged for photomultiplier tubes using a negative power supply.—*Radiation Counter Laboratories, Inc., Skokie, Ill.*



For more information circle **380** on inquiry card.

POWER SUPPLIES

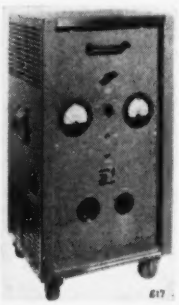
Regulated D-c. Supply

New "Model 6080" variable regulated d-c. power supply provides output of 0-40 volts d.c., 30 amps. Regulation is 0.3 volts with load variations from minimum to maximum and line variations between 100 and 130 v.ac.; is accomplished in less than 0.2 second. Output ripple is less than 4 percent at full load. Input and output circuits are protected by circuit breakers.—*Instrument Laboratory Service, 10701 Briggs Rd., Cleveland, Ohio.*

For more information circle **381** on inquiry card.

6- and 12-volt D-c. Supply

New "Nobatron Model MA6/15" tubeless 6- and 12-volt regulated d-c. supply, using magnetic amplifier principles, is intended primarily as a test instrument for use in checking automobile window motors, heaters, radios, ignition systems, etc., but its high capacity makes it more widely useful: it delivers 100 amps at 6 volts (adjustable to 7.7 v.) or 75 amps. at 12 volts (adj. to 15.4 v.). Regulation is 1 percent against line and load combined.—*Sorensen & Co., Inc., 375 Fairfield Ave., Stamford, Conn.*



For more information circle **382** on inquiry card.

Transistor Power Supply

New "Model 210 Transistor Power Supply" is a regulated dual d-c. unit providing both metered constant current and metered constant voltage outputs for powering all types of transistors and transistor devices. Constant-voltage sections utilize germanium diodes in a bridge rectification circuit. Low-resistance filter components together with use of low-resistance variable auto-transformers for voltage adjustment insure low

EPLAB

Thermopiles

For many years the thermopile has been the accepted instrument for measuring Radiant Heat from Radiant Heaters at the American Gas Association Testing Laboratory in Cleveland, Ohio. Since 1930, when Vandaveer first described his work in this field,* an Eppley thermopile has been used for this purpose in hundreds of tests and the results have been consistent and accurate to within 1 per cent.

This is but one of many applications in the field of radiant energy measurements for which Eppley Thermopiles are ideally suited. They may be obtained with windows of different materials, and various types of black are available for receiver coatings.

All Eppley Thermopiles are supplied with a certificate of calibration, this calibration being made against a Standard Lamp from the National Bureau of Standards.

If you have a problem involving the measurement of radiant energy we invite you to write us, describing your problem in as much detail as possible. We will be glad to make recommendations and there will be no obligation.

*Vandaveer, *Industrial & Engineering Chemistry*, Vol. 22, page 596, June 1930.

BULLETIN No. 3 ON REQUEST—Address: 2 Sheffield Ave., Newport, R. I.

THE EPPLEY LABORATORY, INC.

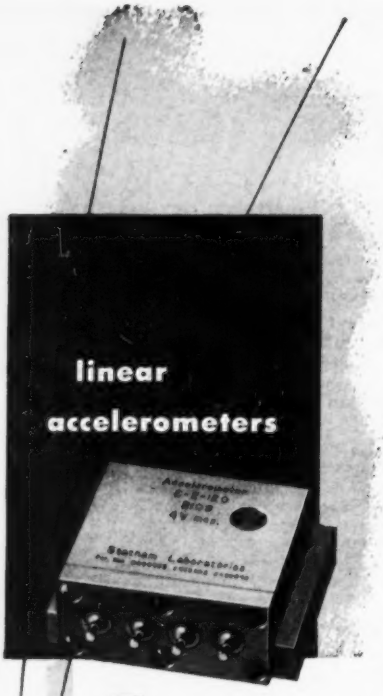
SCIENTIFIC INSTRUMENTS

NEWPORT, RHODE ISLAND, U. S. A.

For more information circle **73** on inquiry card.

A 32 MVA TRANSFORMER BEING TESTED WITH H&B RATIOMETER
It's as easy as looking at your watch ....
when testing the no-load ratio of power transformers with the
NEW "KELLER" TRANSFORMER RATIO METER
References:
Belgium: Constructions Electriques Pauwels S. A., Malines
Canada: Brown, Boveri (Canada) Limited, St. Johns, Quebec
Germany: AEG Transformatoren-Fabrik Stuttgart - Bad Cannstatt
Spain: La Electra Industrial S. A., Tarrasa
Sweden: AB Svenska Transformatorfabriken, Linkoping
Switzerland: Brown, Boveri & Cie. A. G., Baden
Ask for bulletin: Aa 102
H&B
HARTMANN & BRAUN AG FRANKFURT/MAIN

For more information circle **74** on inquiry card.



Linear accelerometers are manufactured by Statham Laboratories for measurement in ranges from ±0.5g to ±1,000g. Unbonded strain gage accelerometers have higher natural frequency than is usually attainable with other types of pickoffs. For maximum possible output, the mechanical construction of these instruments is such that movement of the suspended mass produces a change of resistance of all four arms of the complete balanced bridge. The resistive nature of the bridge permits the use of these accelerometers in either A.C. or D.C. circuits.

Please request Bulletin No. 4.0.

Statham LABORATORIES • Los Angeles 64, Calif.

For more information circle **75** on inquiry card.

NEW INSTRUMENTS

d-c. impedance and hence good output regulation. Constant current is obtained by utilizing high impedance characteristics of a pentode when operating above knee of *Ib-Eb* characteristic. Input a-c. regulation and line isolation for both constant-voltage and constant-current sections is obtained by use of saturable reactors. Dual outputs supply both emitter and collector voltages or currents in any combination positive or negative polarity for point contact, *p-n-p* or *n-p-n* junction or multi-element transistors. Each output current or voltage is continuously variable from zero to maximum and both outputs are isolated electrically from each other. Output No. 1 constant voltage is rated at 75 ma. max. and can be adjusted for 0-1, 0-10, 0-100 volt ranges. Output No. 1 constant current is adjustable from 0 to 30 ma. Current regulation is better than 1 percent. Output No. 2 is rated similarly. Cabinet is 8¾ x 19 x 9 in., for bench or rack mounting.—*Electronic Research Associates, Inc., 715 Main Street, North Caldwell, N. J.*

For more information circle **383** on inquiry card.

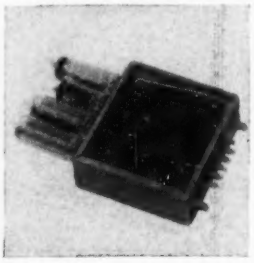
Standard-cell-type D-c. Power Supplies

New "Absolute DC Power Supplies" are said to be like "high-powered standard cells," for calibration and measurement laboratories, strain-gage power sources, as secondary standard d-c. null voltmeters, etc. Feature is automatic comparison of output voltage against a standard cell. Units are said to have "very low hum and noise characteristics," are designed so that a number of complex circuits may be operated from them without cross-coupling.—*Kalbfell Labs., 1076 Morena Blvd., San Diego 10, Calif.*

For more information circle **384** on inquiry card.

Power-supply Regulator

New "Model 1112 Plug-in Power Supply Regulator" regulates power-supply voltage to counter decades, etc.; is said to supply voltages and



currents required by practically all electronic-tube equipment. Input is 305 to 425 volts, d.c.; output is from 170 volts (at 52 ma.) to 280 volts (110 ma.), regulation better than 0.1 percent from no load to full load. —*Clary Multiplier Corp., San Gabriel, Calif.*

For more information circle **385** on inquiry card.

Subminiature H-v. Supply

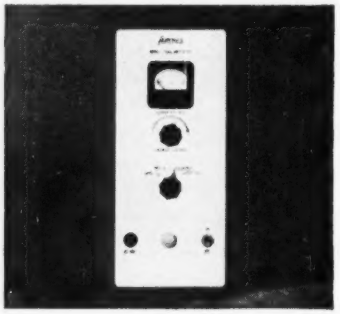
New subminiature transistorized high-voltage power supply for low-current applications (photomultiplier photometers, etc.) weighs 7.5 oz.; is

battery-operated (4 penlite cells can be used). Its d-c. energy conversion efficiency ranges from 30 to 50 percent depending on operating point and input voltage. Expected life is 50,000 hours of operation. Two models: "PS-1," 700 volts; "PS-2," at 900 volts. Both have voltage regulation to 15 volts and a maximum current output of 50 microamps.—*Technical Operations, 6 Schouler Court, Arlington, Mass.*

For more information circle **386** on inquiry card.

Regulated-frequency Power Supplies

New "Model 700-A Frequency-stabilized Power Amplifier" has for its basic function to stabilize the speed of a synchronous motor over a broad range of frequencies, by means of a-f. control independent of commercial power line variations. Drive unit consists of a tuning fork oscillator with temperature coefficient of 1



ppm./deg. C. and appropriate counter-type dividers. Power output is over 100 watts into resistive load of 125 ohms, voltage 0 to 115 or higher. A selector switch connects any one of four inputs: a-c. line, frequency standard unit, external control signal, or external oscillator signal. Companion to "Model 700A" is "Model 702A": identical in construction but without drive unit. Its full-power output frequency is 50 to 1000 cps. but frequency range can be considerably extended above and below these figures at somewhat lower efficiencies. —*Fairchild Recording Equipment Corp., Whitestone, L. I., N. Y.*

For more information circle **387** on inquiry card.

Regulated Power Supply

New "Model 2400 Voltage Regulated Power Supply" features two regulated B supplies completely isolated from each other, one regulated C supply and two unregulated filament supplies isolated from each other. Each B supply is continuously variable from 0 to 400 volts and delivers up to 150 ma. In 20-400-v. range, output voltage variation is less than 0.5 percent for line and load variations. C supply is continuously variable from 0 to 150 volts, delivers up to 0.5 ma. Each filament supply delivers 6.3 volts, 10 amps. Filament supplies may be used separately, in parallel or in series.—*Kepco Labs.*, 131-38 *Flushing Ave., Flushing* 55, *N. Y.*

For more information circle **388** on inquiry card.

Klystron Power Supply

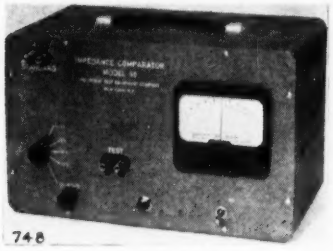
New "Model TVN-11 Klystron Power Supply" supplies beam, reflector, filament, and modulation voltages, (all regulated) for operation of low-power reflex microwave oscillator tubes. All controls, connectors, fuses, and a 4.5-in. illuminated beam current and voltage indicator are located on front panel. Steel cabinet with panel drilling suitable for standard rack mounting.—*Browning Laboratories, Inc.*, 750 *Main St., Winchester, Mass.*

For more information circle **389** on inquiry card.

TESTING AND INSPECTION

Impedance Comparator

New "Model 60 Impedance Comparator," for production line testing of resistors, capacitors, and inductors, indicates percentage deviation of



component under test from a standard component. Four ranges: 1, 5, 10 and 20 percent full scale. No zero adjustment is required and range calibration is readily performed by means of a built-in standard.—*Industrial Test Equipment Co.*, 55 *East 11th St., New York* 3, *N. Y.*

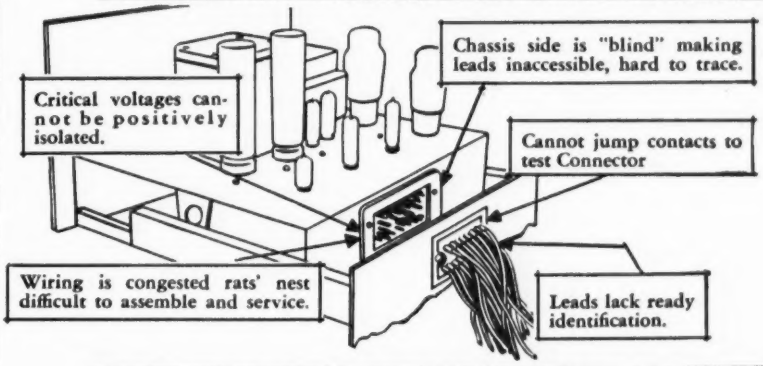
For more information circle **390** on inquiry card.

Leak-testing Machines

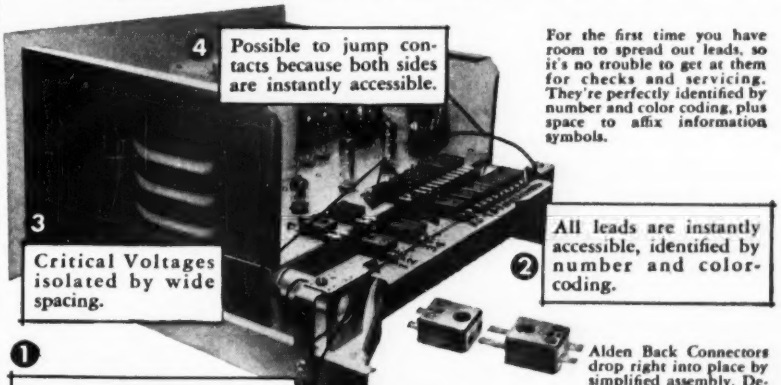
New air-operated, electrically-controlled vertical pressure testing machines detect and locate leaks in castings as well as brazed, welded and soldered assemblies; subject parts to a 10-second automatic check in which the part (or a specified area in the

A new approach to the Rack-and-Panel Connector problem that provides 30-second replacement and single, accessible point of check for all leads:

Up to now, available connectors have forced the massing of leads in congested arrangements hard to trace and service.


Chassis side is "blind" making leads inaccessible, hard to trace.
Critical voltages cannot be positively isolated.
Cannot jump contacts to test Connector
Wiring is congested rats' nest difficult to assemble and service.
Leads lack ready identification.

NOW . . . you can organize your connectors so that they are spread out and accessible like this —

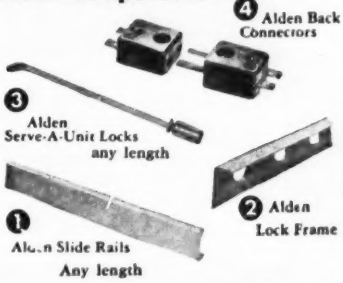

4
Possible to jump contacts because both sides are instantly accessible.
3
Critical Voltages isolated by wide spacing.
2
All leads are instantly accessible, identified by number and color-coding.
1
Connectors are spread out in an orderly row, giving a central point of check.

For the first time you have room to spread out leads, so it's no trouble to get at them for checks and servicing. They're perfectly identified by number and color coding, plus space to affix information symbols.

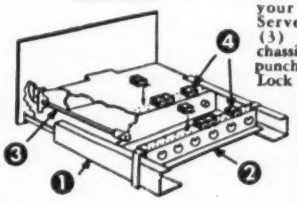
Alden Back Connectors drop right into place by simplified assembly. Designed to avoid surface leakage and other flashovers. Don't need special insulation or expert soldering techniques. Built rugged to compensate for wide sheet metal tolerances.

FOR ANY CHASSIS, it's as simple as THIS —

Take these Standard Alden Components —



Arrange them like this —



Arrange Alden Side Rails (1) and Alden Lock Frame (2) to suit your chassis. Alden Serve-A-Unit Locks (3) mount in your chassis to engage pre-punched holes in Alden Lock Frame (2) to pilot, draw in, lock or eject. Arrange Alden Back Connectors (4) in orderly row on Alden Lock Frame. Mount mating Alden Back Connectors on Your Chassis.

AND YOU GET 1) Chassis that plugs in, locks and ejects with half turn of the wrist; 2) leads so beautifully organized, accessible and identified that non-technical personnel can service.

137 N. Main St., Brockton 64, Mass.

ALDEN PRODUCTS CO.

SEND FOR FREE SAMPLES OF ALDEN BACK CONNECTORS

— Also request free "Alden Handbook", 226 pages of techniques and components for Unitized Plug-in Unit Construction.

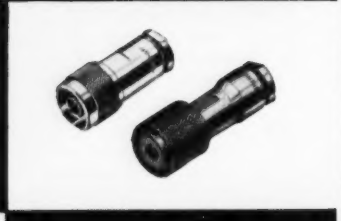
For more information circle **76** on inquiry card.

an Amphenol guide to Quality Components

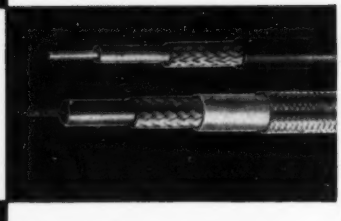
AMPHENOL

A N CONNECTORS – AMPHENOL is the leading manufacturer of approved A N connectors. These have many features unique with AMPHENOL, including gold-plated contacts, and many features now standard in government specifications that were initiated by AMPHENOL, such as machined coupling rings and dielectric material, 1-501.

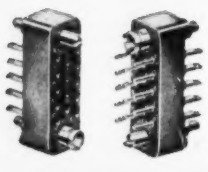
R F CONNECTORS – Manufactured strictly to government specifications, AMPHENOL R F connectors feature never-failing continuity, perfect match and tested AMPHENOL construction. Giving years of top performance, they provide the most efficient linking of coaxial cables now available to the electronics industry.



COAXIAL CABLES – Quality control makes the difference in AMPHENOL coaxial cables. Manufactured to the closest tolerances and inspected during every phase of this manufacturing, AMPHENOL coaxial cables are available with many different types of dielectrics and jackets – premium materials help assure quality performance.



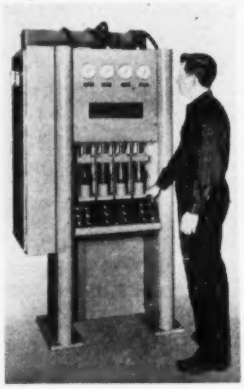
SPECIAL CONNECTORS – Many connectors are made by AMPHENOL to assist manufacturers with individual problems in the interconnection of electronic equipment. These include the famous BLUE RIBBON connectors and many types of standard and miniature electrical connectors. AMPHENOL can help you with your problems, too.



brand new–*the* AMPHENOL A-3 Catalog *contains up-to-date electrical and mechanical details on all* AMPHENOL *A N and special connectors. For complete information on these, send for your copy of* Catalog A-3.

AMERICAN PHENOLIC CORPORATION
AMPHENOL
chicago 50, illinois

part) is charged with a given volume of compressed air. Loss of air pressure, caused by a leak or flaw, is indicated by signal lights through an extremely sensitive measuring sys-

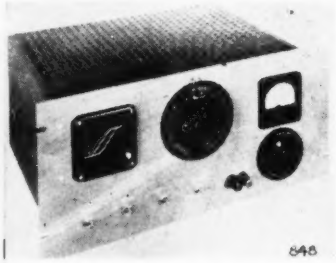


tem. New machines are designed to provide maximum production speed with minimum loading time. Machine illustrated detects and locates leaks in a rifle grenade assembly fabricated by soldering together several spun copper parts. Four test stations permit testing four grenades at a time. Two stations are unloaded and loaded while two stations are making 10-second air check.—*Hautau Engineering Co., 721 Wanda, Ferndale 20, Mich.*

For more information circle **391** on inquiry card.

Inductance Bridge

New "Type 1002-A Incremental Inductance Bridge" is claimed to make obsolete complicated test equipment for measuring inductance of iron-



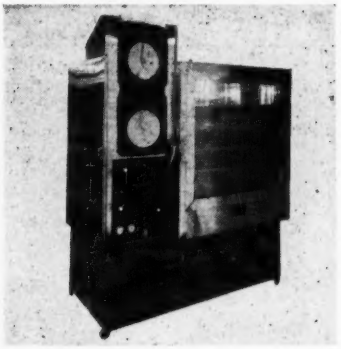
cored inductors when there is a d-c. component of current present. It includes a CRT indicator and is ready for operation when connected to power line. Range of values obtainable is 1 to 200 henries; direct current values of 1 to 500 ma. can be selected by operator.—*Waters Manufacturing, Inc., 4 Gordon St., Waltham 54, Mass.*

For more information circle **392** on inquiry card.

Temperature and Humidity Test Chambers

New "Model 15-CF Atmosphere Control Cabinet," for any type moisture-vapor tests within limits of –20 F. to 150 F. and relative humidity of

←——Circle **77** on inquiry card

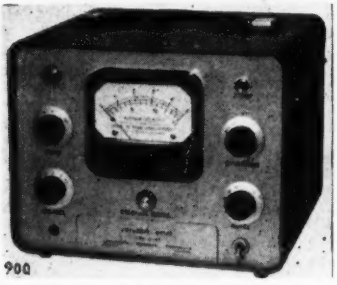


35 percent to slightly under 100 percent, is suitable for testing foods, greases, oils, packaging materials, plastics, tools, etc., which may be affected by temperature and humidity. It may be ordered equipped with conventional or electronic controls.—*Package Materials Lab., Inc.*, 461 *Crescent Rd., Hatboro, Pa.*

For more information circle **393** on inquiry card.

Vibration Meter

New "Type 1-117 Vibration Meter" may be used for field tests, trouble-shooting, in the laboratory, or as a "go-no-go" gage for production qual-



ity-control testing. For permanent test installations, entire chassis and panel may be rack mounted. Instrument weighs 25 lbs. with three accessory filters installed and can be used wherever standard 115-v. 50/60/400-cps. power is available. Suitably matched self-generating pickups are the only external items required for its operation. Up to four of these may be mounted on body under test and connected to instrument's rear panel. Gain on each input channel can be adjusted individually. Where unwanted low-frequency signals interfere with desired frequency, three accessory high-pass filters may be used to cut off sharply at 30, 70, or 110 cps. Measured values of both linear and torsional velocity of motion and peak-to-peak displacement are indicated on a direct-reading scale.—*Consolidated Engineering Corp., Pasadena 8, Calif.*

For more information circle **394** on inquiry card.

X-band VSWR Meter

New "Model 110A" x-band voltage standing wave ratio indicator, for laboratory or production-line testing of waveguide components, covers 8500-9600-Mc. band, includes an oscillator, wavemeter accurate to 1 Mc. to supplement approximate direct-

WITH FOUR-WINDOW

X-RAY TUBE FLEXIBILITY

★ The effective line focus of the NORELCO basic X-ray Diffraction Unit is 0.06 x 10 mm. This unique line focus X-ray tube provides an effective slit source of intense radiation affording maximum resolution in shorter exposure times for diffractometry.

Radiation output from four windows provides opportunity to extend the utility of the basic X-ray Diffraction Unit —to operate two goniometers from the two slit sources and a choice of cameras from two simultaneously available spot sources. This single feature increases operational speed and overall efficiency over other designs with fewer X-ray windows. An *exclusive* NORELCO feature.

A Norelco PRODUCT NORTH AMERICAN PHILIPS COMPANY, INC.

Serving Science and Industry

Dept. IM-11 • 750 South Fulton Ave., Mount Vernon, N.Y.

In Canada: Rogers Majestic Electronics Ltd., 11-19 Brentcliffe Road, Leaside, Toronto 17, Ontario

For more information circle **78** on inquiry card.

Photos Courtesy The Massey-Harris Company.

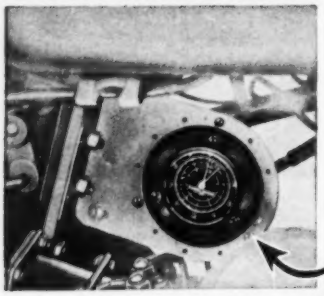
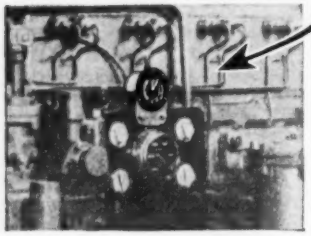


Photo Below Courtesy Cummins Engine Company, Inc.



The Sure Way to "Design out" Vibration and Shock Damage.

Lord Meter Mountings are paying dividends to manufacturers and users of heavy duty industrial and farm tractors, lift trucks, stationary engines and many other industrial machines where shock and vibration are encountered.

The Lord Meter Mount assures the accurate performance designed into Hobbs Engine-Hour Meters when they are subjected to excessive vibration on farm tractors and stationary diesel engines. These meters are protected from the damaging effects of vibration and shock by the unique method of combining shear and rolling action of the rubber to absorb destructive forces. The outer ring is mounted to the panel and the inner ring holds the meter thus giving protection in multi-planes. The rubber between these rings does the work. We will be pleased to have the opportunity to help you in the application of Lord Meter Mountings.

BURBANK, CALIFORNIA 233 South Third Street
DALLAS, TEXAS 413 Fidelity Union Life Building
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DAYTON 2, OHIO 410 West First Street
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NEW YORK 16, NEW YORK 280 Madison Avenue
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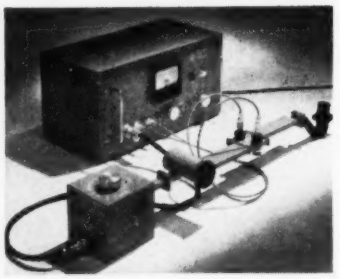
CLEVELAND 15, OHIO 811 Hanna Building

LORD MANUFACTURING COMPANY • ERIE, PA.

LORD BONDED RUBBER — *Headquarters for* **VIBRATION CONTROL**

For more information circle **79** on inquiry card.

NEW INSTRUMENTS

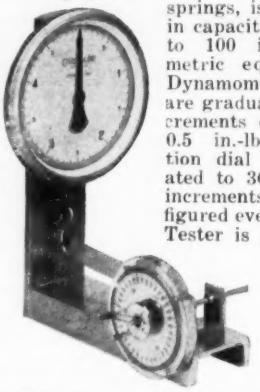


reading dial of oscillator, a forward and reversed directional coupler with bolometer take-offs for source and reflected power and a direct-reading ratiometer having dual scales calibrated directly in vswr: 1.06 to 1.3 and 1.3 to 2.5—*Color Television Inc., 952 E. San Carlos Ave., San Carlos, Calif.*

For more information circle **395** on inquiry card.

Torsion Spring Tester

New "Model 942 Medium Capacity Torsion Spring Tester," designed to test right-hand and left-hand torsion springs, is available in capacities from 5 to 100 in.-lbs. or metric equivalent. Dynamometer dials are graduated in increments of 0.02 to 0.5 in.-lbs. Deflection dial is graduated to 360 deg. in increments of 1 deg. figured every 10 deg. Tester is accurate



within 1 percent. Photo shows tester set up to test left-hand springs. Deflection dial is easily removed to rear operating shaft for testing right-hand springs. Adapters are usually necessary and complete drawings and specifications are supplied with tester.—*John Chatillon & Sons, 85 Cliff St., New York 38, N. Y.*

For more information circle **396** on inquiry card.

Flat Plate Camera for X-ray Diffraction

New "Norelco" flat plate camera can be used for investigations which cannot be handled effectively with a powder camera or a diffractometer: is useful for Laue work, or with mono-

chromatic or filtered radiation. It comprises: (1) stationary specimen mount accommodating not only planar sections of metals, crystals, compacted powders or plastics but also wires, organic or inorganic fibers, powder specimens mounted on fibers, or powders or liquids in capillary tubes; (2) combination collimator mount and motor-rotated back-reflection cassette; (3) forward reflection cassette which can also be utilized as a specimen support, with motor drive for rotation.—*Research & Control Instruments Div., North American Philips Company, Inc., 750 South Fulton Ave., Mount Vernon, N. Y.*

For more information circle **397** on inquiry card.

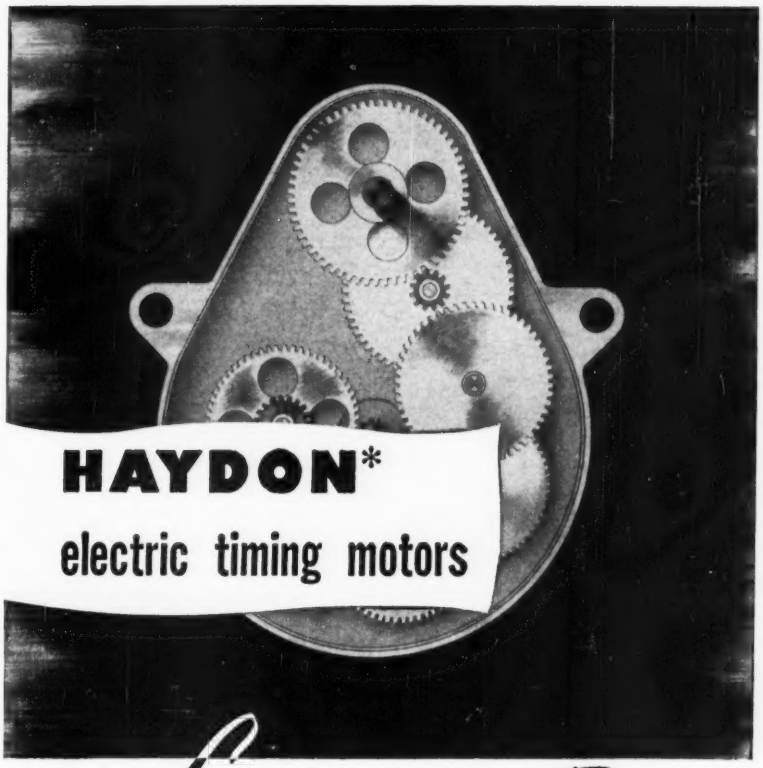
Smoothness Tester

New design of "Bekk Smoothness Tester" yields numerical measurement of smoothness of any paper, paper-backed, or plastic material. Original design is standard equipment in paper, board and printing industries; as both Government Printing Office and all Armed Services specify "Bekk number." Redesign includes plastic material since smoothness factor in both paper and plastic are closely related.—*R. Fuess, Inc., 39 W. 60th St., New York 23, N. Y.*

For more information circle **398** on inquiry card.

Bridge Test Sets

New "Series 301" Wheatstone bridge test sets weigh approx. 8 lbs. including self-contained batteries. Accuracy is 0.1 percent +0.01 ohm. For measuring resistance values above 100,000 ohms, an external battery may be used. Besides resistance measurements, new units are adapted for location of line faults. Switches and



Leaders in the Field

OF TIMING COMPONENTS

HAYDON, in addition to its own extensive development, engineering and production facilities has the backing of the basic research facilities of the General Time Corporation. The wide experience of associated companies, Westclox, Seth Thomas, Stromberg Time and Western Clock are also available.

These wide resources have resulted in HAYDON's unquestioned leadership in the field of timing.

Write for Catalog No. 322, Electric Timing Motors

Other literature available on request on Timing Devices, Clock Movements, 400 cycle Elapsed Time Indicators, 400 cycle Time Delay Relay, 400 cycle Motors, D.C. Motors.

*TRADEMARK Reg. U. S. Pat. Off.

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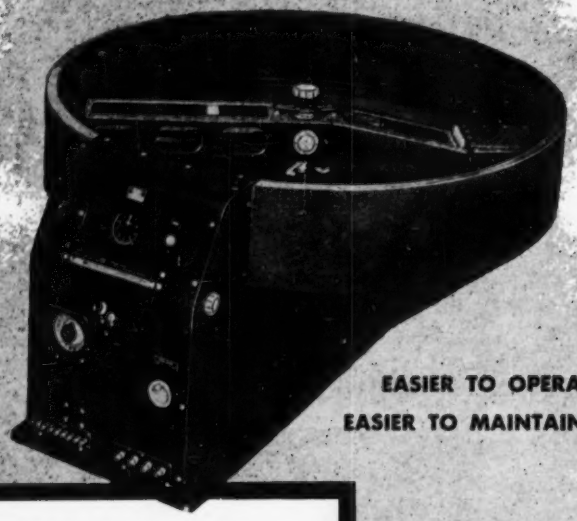
AT TORRINGTON
HEADQUARTERS FOR
TIMING

HAYDON Mfg. Co., Inc.
Subsidiary of GENERAL TIME CORP.
2035 ELM STREET
TORRINGTON, CONNECTICUT

For more information circle **80** on inquiry card.

GENISCO'S MODEL B G-ACCELERATOR



EASIER TO OPERATE!
EASIER TO MAINTAIN!

Rugged, low cost unit provides fast, accurate calibration of accelerometers and other equipment under operational acceleration forces.

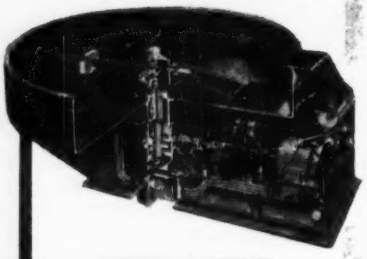
The mounting platform of the Genisco Model B, G-Accelerator accommodates instruments up to eight cubic inches in volume and 25 pounds in weight. Boom rotation is variable between 5 and 420 RPM, and is controlled by a single handwheel on the control panel. Maximum drift is less than 0.1% per minute, and maximum wow above 10 RPM less than 0.5%. The range of G-loadings is from .017 to 120 G's at the maximum radius of gyration of 24 inches.

Three separate instruments assure accurate RPM measurement!

A built-in, line frequency strobe disc system accurately measures boom speed at 82 harmonics over the full RPM range. In-between speeds can be determined by a counter-and-timer which counts boom revolutions, in any adjustable time interval, to the nearest 1/10 of a revolution. A standard aircraft sensitive tachometer, accurate within 1%, is also provided for rough speed indication.

Electrical leads have extremely low noise levels!

Eight solid silver slip rings are normally provided. These are designed for instrumentation rather than for power leads. Each is individually shielded and has a precious metal brush, resulting in noise levels so low oscilloscopes may be used at highly sensitive settings. Standard current carrying capacity of each slip ring circuit is 0.5 amperes continuous duty, with maximum resistance ½ ohm. Combinations of power and instrumentation rings can be supplied.



OPTIONAL EQUIPMENT AVAILABLE

1. **OPTICAL SYSTEM**...for observing instruments while subjected to G-loadings.
2. **AIR SYSTEM**...four ¼", leakproof pressure or vacuum ports for gas or liquids.
3. **OVERHEAD SLIP RING ASSEMBLY**...provides additional power or instrumentation slip rings.
4. **ACCESS DOORWAY**...for ease in mounting test instruments.
5. **COVER ASSEMBLY**...conserves power by minimizing air pumping action, keeps dust out.
6. **DEEP GUARD RAIL**...16" deep, provides more clearance above mounting table.

For detailed specifications on the Genisco Model B, G-Accelerator write to the Director of Sales, Genisco, Inc., 2233 Federal Avenue, Los Angeles 64, California.

Genisco INCORPORATED

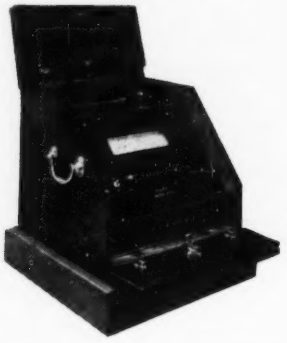
For more information circle **81** on inquiry card.

terminals are provided for fast conversion of Wheatstone bridge circuit to Varley, Murray, Hillborn, Fisher, and other loop tests; and capacitance-balance method of fault location may be used.—*The Winslow Co., 9 Liberty St., Newark 5, N. J.*

For more information circle **399** on inquiry card.

Moisture Meter

New "Kappa Electronic Moisture Meter" operates at radio frequency on capacity change principle; is capable of measuring moisture content

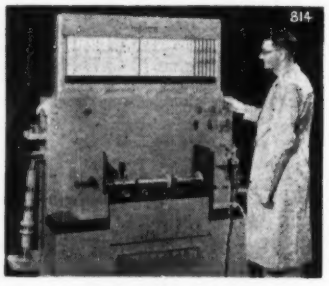


of a substance with water content as low as 0.5 percent and, at other end of scale, as high as 70 percent. Instrument is available in two degrees of sensitivity: "S" Type has an expanded scale between zero and 15 percent moisture; "All-Purpose Type" permits a discrimination better than 0.07 percent moisture.—*Dep't IM, Marconi Instruments Ltd., 23 Beaver St., New York 4, N. Y.*

For more information circle **400** on inquiry card.

Crankshaft Inspector

New "Precisionaire Crankshaft Gaging Machine" gages forty-three dimensions and conditions, so that a comparatively unskilled operator can

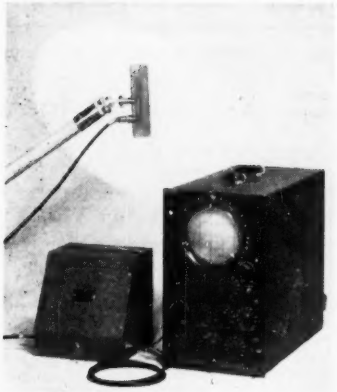


promptly check critical dimensions on a crankshaft and tell which are acceptable, oversize, or undersize by simply viewing float positions in 36-column "Precisionaire."—*The Sheffield Corp., Dayton 1, Ohio.*

For more information circle **401** on inquiry card.

Corona Detector

New device for detecting surface corona discharge consists of a probe mounted at end of a 10-ft. insulating pole, a control box, and necessary

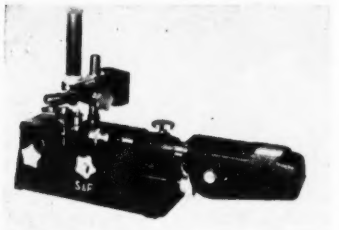


connecting cables. In operation, control box is connected to a standard oscilloscope (not part of equipment) which gives a visual indication of corona. Operating power is furnished by a 67.5-volt dry cell battery and a 1.5-volt dry cell filament battery. Resonant frequency of unit is 10 kc.—*General Electric Co., Schenectady 5, N. Y.*

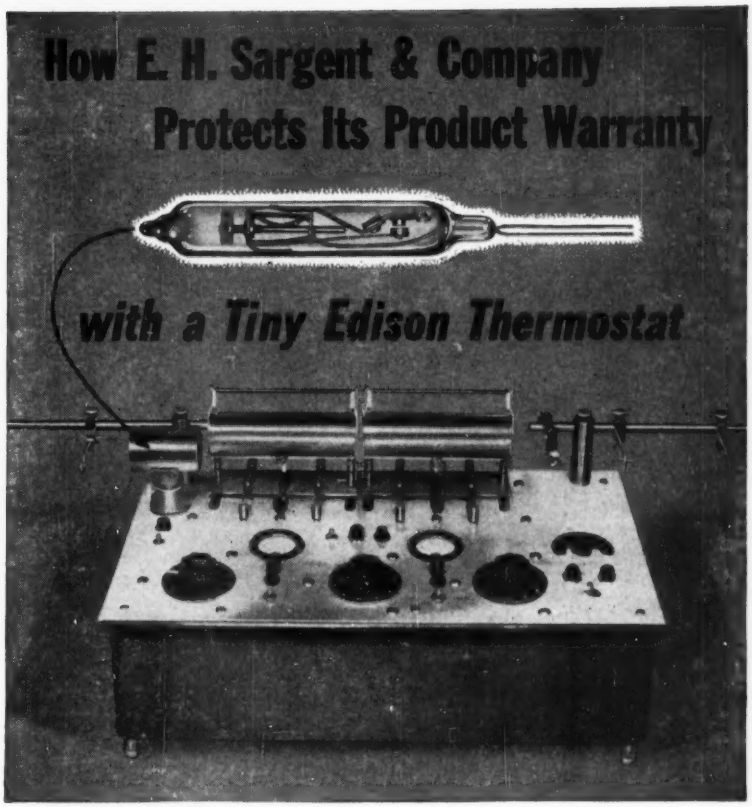
For more information circle **402** on inquiry card.

Fine-pitch Gear Tester

New "S & F" Two-flank Universal Gear Tester," for inspection of all types of fine-pitch gears, differs from domestic equipment designed to



test one particular type gear: it can be used for inspection of spur, bevel and helical gears; worms and worm gears; flat and round racks; pinion-shafts; finished and semi-finished gear assemblies; and extremely small gears and pinions used in instruments and dial gages. It operates on principle recommended in American Standard Inspection of Fine Pitch Gears—rotation of test gear in contact with a master gear: both flanks of test gear are in contact with master, so that gears mesh without backlash. Basic instrument provides for visual indication, on a dial indicator, of all errors affecting performance of a gear under operating conditions. Addition of a "Graphotest" provides a permanent graphic recording of errors, simplifies analysis of total composite error into its components of runout and tooth-to-tooth composite error. Magnifications of 100, 200, 250 or 400 are available in "Graphotest." Tester can be supplied for either hand or motor-driven rotation of the gears. For high-production testing, a semi-automatic model can be furnished. Gears are illuminated from below, enabling operator to see that gears are meshing correctly, and to reveal presence of dirt or chips. If desired, a 30-



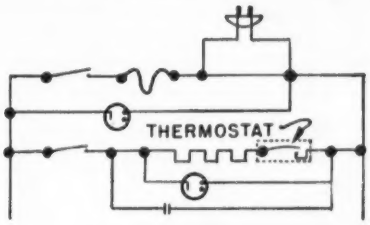
E. H. Sargent & Company Automatic Micro Combustion Furnace.

Absolute accuracy and exact reproducibility of repeat chemical analyses are made possible by Edison *sealed-in-glass* Thermostats.

SPEED, accuracy and exact reproducibility are a few of the qualities designed into E. H. Sargent & Company's line of micro combustion furnaces. Advanced engineering methods and reliable components are necessary for dependable performance.

A VITAL COMPONENT in these instruments for analyzing a compound for its carbon and hydrogen content is an EDISON type S1-1A thermostat. It controls the temperature of the lead dioxide absorbent in the combustion train to insure the complete removal of all nitrogen oxides before the gases are passed into the final absorbing tubes for weighing. The mortar containing the absorbent is held to 177° C ± 2° C. Below temperature the absorbent does not remove the oxides of nitrogen efficiently and above temperature the absorbent starts to decompose and may release the oxides already absorbed. Any substantial temperature variation may cause an error in the final determination.

THE SARGENT high speed radiant heat furnace can operate for extended periods at



900° C and is designed for rapid cooling. The thermostatic control in the mortar must be responsive yet accurate and able to stand up for years without drift or change in setting.

EDISON THERMOSTATS feature stability measured in years, control within ± 0.1° F and capacity to 115 volts, 8 amperes d.c. or 1000 watts. EDISON temperature control engineers will be glad to work with you on the solution of your ambient protection problems. Just call or write to:

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For more information circle **82** on inquiry card.

MINIATURE
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gyros

TWO AXIS GYRO
3¼ in. dia., 5 in. long
Weight 3.5 lbs.

AIRCRAFT RATE GYRO
2¼ in. dia. 3 in. long
Weight .85 lbs.

RATE & FREE GYROS

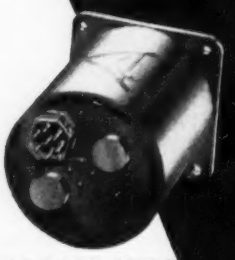
Fully Floated Construction

Hermetically Sealed

No Heating Required From -65° to 200° F

Satisfactory Operation Under Extreme Vibration And Acceleration Conditions

Designed For Maximum Performance With Minimum Accessory Equipment



MISSILE RATE GYRO
2¼ in. dia. 2¼in. long
Weight .70 lbs.

AMERICAN GYRO
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1509 COLORADO AVE.
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For more information circle 83 on inquiry card.

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MICRO FLAT
BLACK GRANITE SURFACE PLATES

PERFECT PRECISION
Avoid substitutes

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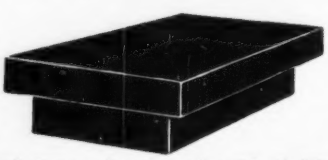
Present an absolute continuous bearing surface, finished up to 50 millionths inch. Incredibly smooth. Falling objects do not cause humps. Being harder than hardened steel, can take greatest mistreatment without causing inaccuracy of surface. No oiling. Will not rust or warp. No re-scraping. Most durable.



COLLINS MICROFLAT CO., 2326 East 8th Street, Los Angeles 21, Calif.

For more information circle 84 on inquiry card.

NEW INSTRUMENTS

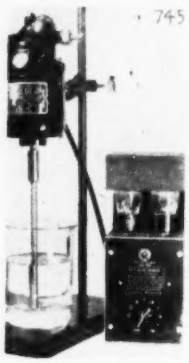
power microscope can be fitted on top. Replacement parts and service facilities in Cleveland, Detroit and Newark.—*Kurt Orban Co., Inc.*, 205 *E. 42nd St., New York* 17, *N. Y.*

For more information circle **403** on inquiry card.

FOR THE LABORATORY

Laboratory Mixer

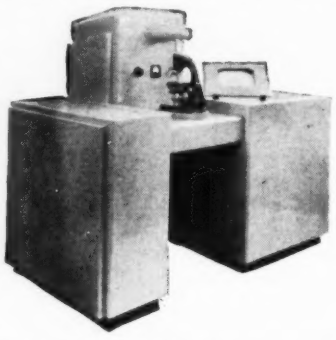
New "GT-21" mixer provides advantages of controlled-speed d-c. motor; operates from a-c. outlet. New closed-cycle circuit assures unvaried torque (as demanded by mixes that develop viscosity) over entire armature shaft speed range of 0 to 5,000 rpm; either direction. Gear ratio 18:1. Thyratron tubes supply more current than needed to operate motor. Mixer comes complete with mounting bracket; two shafts with couplings to be attached to either motor shaft—one with a 1.5-in. propeller and one with a heavy paste paddle; three-jaw ⅜-in. chuck; three-step pulley to fit either shaft; and hollow-head wrenches for set screws.—*Gerald K. Heller Co., Ridgeley & Worcester S'ts., Baltimore* 30, *Md.*



For more information circle **404** on inquiry card.

Flying-spot Microscope

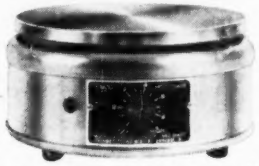
New "Flying Spot Microscope," said to be "a new and revolutionary electronic device for investigation and application in the field of microscopy," combines microscope and flying scanner—a method of converting two-dimensional density distribution into a varying voltage-time relationship suitable for transmission. Complete equipment is in console form. Resolution up to 100,000 lines per inch; magnification 350 to 8,000 times; scan tube afterglow less than 1 usec.; monitor tube afterglow approx. 15 seconds; number of visible lines 350.—*Marconi Instruments Ltd., 23, Beaver Street, New York* 4, *N. Y.*



For more information circle **405** on inquiry card.

Hot Plate

New "Model 2500" is a 7-in. diam. 660-watt addition to maker's line of laboratory and industrial hot plates. Its thermostat provides stepless con-

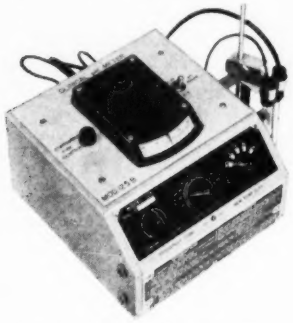


trol from room temperature to 270 C., with surface-temperature variation less than 3 deg.—*Thermo Electric Mfg. Co.*, 496 *Huff St., Dubuque, Iowa.*

For more information circle **406** on inquiry card.

Blood pH Meter

New "Model 125B Clinical pH Meter" has been especially developed for pH measurements of highest sensitivity and accuracy within comparatively narrow range of pH values en-

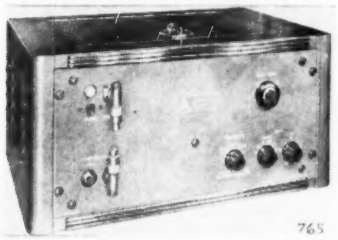


countered in blood. Operator can easily reach reproducible accuracy of 0.01 pH for all normal and pathological specimens in clinical work. Instrument is essentially maker's "Model 125" modified to expand 6.0-8.0 range over entire scale; but it can be used for 2.0-12.0 range on other body fluids, on bacteriological preparations, etc.—*Photovolt Corp.*, 95 *Madison Ave., New York* 16, *N. Y.*

For more information circle **407** on inquiry card.

Spectrometry Amplifier

New "Oak Ridge A1C Linear Amplifier, RCL Mark 15 Model A1C," (ORNL spec. Q-1302) retains features of "Oak Ridge A1 Linear Amplifier" and is modified for spectrometry applications as follows: (1) higher counting rate made possible by a 1-usec. RG 65/U delay line pulse-shaping circuit inserted instead of 2-Mc. bandwidth switch position; (2) it requires an input signal six

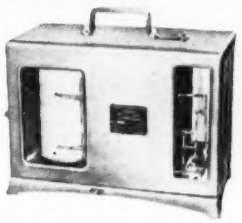


765

PRECISE

AIR INSTRUMENTATION BY BENDIX-FRIEZ

FOR RECORDING TEMPERATURE, HUMIDITY



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PORTABLE TEMPERATURE, HUMIDITY RECORDER Rugged, compact design. Ideally suited for use in small space and difficult locations. Provides convenient 3 x 5 charts for 10 or 30 hour records.

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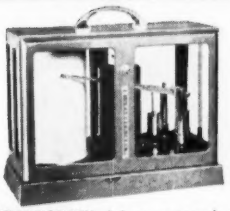
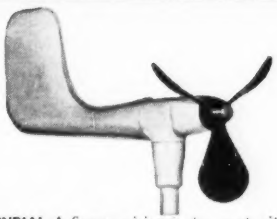


MICROBAROGRAPH A key meteorological instrument. Records atmospheric pressure to within 0.01 inch mercury. Record chart expanded 2½ times for greater visibility.

ANEROID BAROMETER Inexpensive, dependable, easy-to-read. Shows pressure and barometric tendency. Housed in handsome brass case. Favored by professionals and amateurs alike.

FOR MEASURING WIND SPEED, DIRECTION



WINDIAL A fine precision instrument with large dials that show wind speed and direction at a glance. Popular with smaller airports, yacht clubs, schools, plants, etc.

AEROVANE Indicates and records wind speed and direction. Recognized as "best all-purpose wind measuring instrument yet devised." Readily installed and easily maintained.

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For more information circle **85** on inquiry card.

The Gaertner
TOOLMAKERS' MICROSCOPE

For use wherever precision measurements are required in shop inspection or layout procedures.

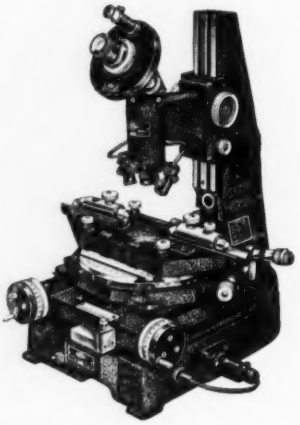
INCH OR METRIC UNITS

Coordinate Measurements
Left to Right.....100 mm or 4 inches
Front to Rear..... 50 mm or 2 inches

Direct Reading to 0.002 mm or 0.0001 inch

Angular Measurements

Stage Range	360°
Reading with Vernier	1 min.
Protractor Circle Range	360°
Reading with Vernier	1 min.
Magnification	30X
Microscope Column Tilt	±8°



- **Detects errors in cutting tools.**
- **Checks threads and thread gages.**
- **Measures critical dimensions on machine and instrument parts.**
- **Adaptable to flat work, round work, odd shapes.**

A completely illustrated booklet presenting detailed information on all models and accessories and suggesting applications.

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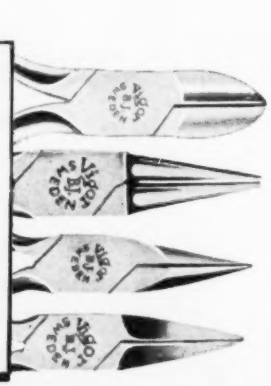
COMPETITIVELY PRICED! It costs no more to use these superb imported Swedish steel pliers! Hand-forged for strength; hand-machined for precision; hand-finished for high polish. All styles—a variety of sizes in each style—all with box joints. For information write

B. JADOW, *inc., N. Y.*
860 B'way at 17th St.



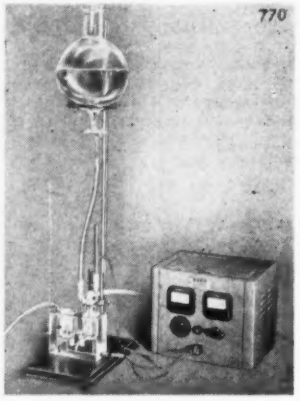
For more information circle **87** on inquiry card.

times larger than signal necessary for full-sized output, to produce a 2 percent base-line deflection, which recovers with a 200-usec. time constant; (3) output signal linearity improved for spectrometry applications; (4) more precise settings may be achieved; (5) pulse height selector output is negative, and is 20 or more volts in amplitude.—*Radiation Counter Laboratories, Inc., Skokie, Ill.*

For more information circle **408** on inquiry card.

Electric Desalter

New "RECO" electric desalter eliminates difficulties in chromatography of amino and organic acids: it removes inorganic salts without



equivalent losses in organic and amino acids.—*Research Equipment Corp.*, 1135 *Third St., Oakland* 20, *Calif.*

For more information circle **409** on inquiry card.

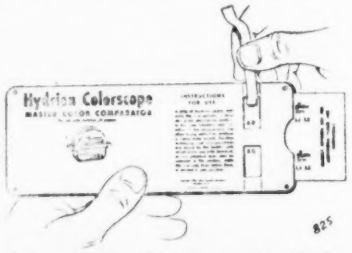
Metabolism Cages

New "Roth" glass cages for use in metabolic studies of carbon-14-labeled compounds are available in small size for mice, large size for rats; or designs and sizes to order. Designed for collecting urine volumes and expired air from rats and mice injected with tracers, they provide a method of continuous feeding with a minimum of food contamination.—*Dept. WPF-9, Wakefield Industries, Inc.*, 5108 *W Grove St., Skokie, Ill.*

For more information circle **410** on inquiry card.

pH Color-comparison Device

New "Colorscope" is a new pocket device that facilitates color comparisons with "Hydrion" pH test papers. Its color charts reproduce colors shown by "Hydrion" papers at 41



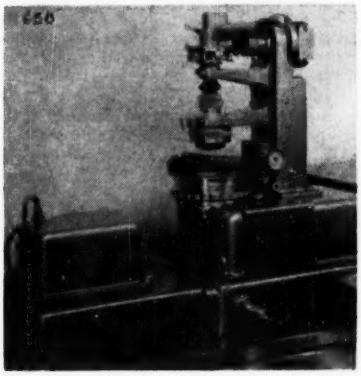
points on pH scale. These color blocks are larger than regular "Hydrion"

colors, and are printed on sliding panels fitting into housing, with two windows for color comparisons. Imprinted on device are tables of conversion factors and pH values of various chemicals.—*R. P. Cargille Laboratories, Inc., 117 Liberty St., New York 6, N. Y.*

For more information circle **411** on inquiry card.

Microscopic Attachment for Infrared Spectrometer

New microscope attachment for infrared spectrometer gives infrared spectra of a single crystal, a single



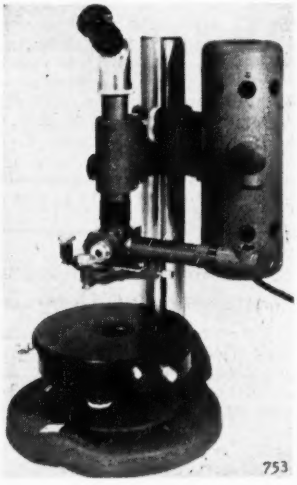
fiber, microscopic tissues, etc. Optical system, being made up of reflecting elements, is free of chromatic aberration. Optical path can be flushed with dry nitrogen to minimize CO_2 and H_2O absorption bands.—*The Perkin-Elmer Corp., Norwalk, Conn.*

For more information circle **412** on inquiry card.

OPTICAL INSTRUMENTS

Multiple-interference-type Surface-roughness Microscope

New "Multiple Interference Microscope" utilizes a modification of interferic method, whereby measuring accuracy of instrument is as fine as 0.04 microinch (approx. atomic di-



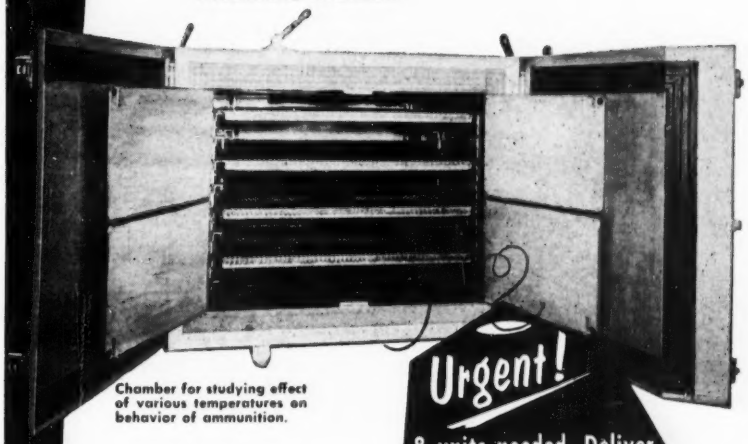
Tenney

"EXPEDITED ENGINEERING"

pays off for

JEFFERSON PROVING GROUND

Madison, Indiana



Chamber for studying effect of various temperatures on behavior of ammunition.

Urgent!

8 units needed. Deliver first 2 in 60 days.

Tenney DELIVERY: Total order in 55 days!

SPECIFICATIONS

Temp. Range: —100°F. to 200°F.
Pull-down: 90°F. to —70°F. in 45 min.
Dimensions: 5' W. x 4' H. x 9' D.
Power: 115-volts, 20 amps.
Weight: 3350 lb.

The problem was urgent: The Army Ordnance Corps needed — *fast* — eight "conditioning boxes", in which Artillery ammunition could be subjected to extreme hot-and-cold temperatures before being test-fired at Jefferson Proving Ground. These chambers had to meet all the requirements — had to be shockproof — had to be completely portable. And TENNEY had to design, build and deliver the first two units within 60 days!

Tenney engineers designed a unit using dry-ice coolers, electric heaters, air circulation and precise thermostatic controls. Construction was rushed and completion of the first unit showed that performance far exceeded contract specifications — pull-down was held at —70° F. for 18 hours with no additional dry ice. Then production rolled . . . and the Army received *all 8 units 5 days before the first 2 were due!*

This is typical of Tenney's "Expedited Engineering," a policy based on years of meeting and solving problems in the design and construction of precision refrigeration, heating, and environmental test equipment. With this background, and manufacturing facilities keyed to meet all possible conditions, exacting specifications are speedily translated into well-engineered equipment . . . and delivered *on time.*

Testing troubles? Talk 'em over with

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Plants: Newark, N. J., Union, N. J., and Baltimore, Md.
Los Angeles Representative: GEORGE THORSON & CO.
Engineers and Manufacturers of Automatic Environmental Test Equipment

For more information circle **88** on inquiry card.

is this your timing problem?
Sorry! A. W. Haydon Company
Can't Help Your Timing Here.
Only a "pro" and practice can straighten you out!
But - - -
We are the "pro's" for precision timing. Come to us with these timing problems. You'll find that we have solved more complex A.C. and D.C. timing problems than just about anybody else. Maybe we have already solved yours. It costs you nothing to find out. Write for catalog.
The A.W. HAYDON COMPANY
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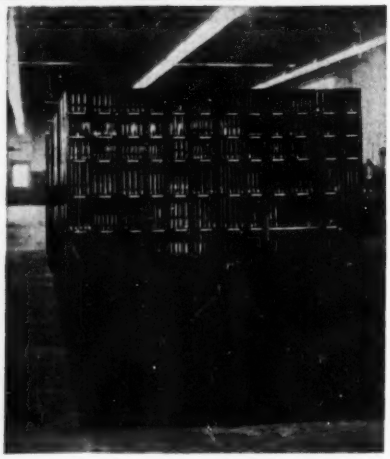
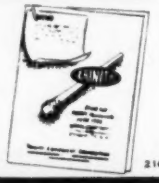


—in a wide variety of designs, sizes and materials.

We will be glad to place your name on the list to receive copies of the monthly Trinity Thermowell Stock List.

• *Request your copy now.* •



2106

TRINITY EQUIPMENT CORPORATION
494 Westfield Ave., East Roselle Park, New Jersey
THERMOWELLS and other Specialties for the Process Industries

For more information circle **98** on inquiry card.

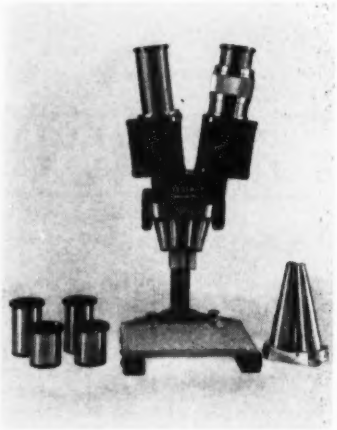
NEW INSTRUMENTS

mension), instead of 2 to 4 microinches which is finest that can be estimated between the 11.6 and 10.9 microinch steps obtained with sodium or mercury monochromatic lights and conventional methods. In new instrument, fringes of conventional interferometers are replaced by lines which constitute real profile curves and contours, exactly reproducing surface shapes. Upper limit of measuring ranges is about 100 microinches as in conventional interferometers, but a new measuring range of 0.04 to 4 microinches (usually covered by electron microscope) is made available. In addition to measuring deviations from absolute (atomic-dimension) smoothness of surfaces, new instrument can measure thickness of biological and industrial membranes and films to 0.02 microinches; can be used also for crystal studies, thermal-expansion measurements, etc. Interference plates must be ordered for each type of application.—*C. E. Johansson Gage Co., 10641 Haggerty Ave., Dearborn, Mich.*

For more information circle **413** on inquiry card.

Stereo Microscope

New model of imported "Edscorp Stereo Microscope" comes with two sets of paired objectives, 3X and 5X, to give user a power range from 15X



to 60X, with three sets of eyepieces, 5X, 8X and 12X. Interpupillary distance is variable. Rack-and-pinion focusing; focusing eyepiece. — *Edmund Scientific Corp., 173 E. Gloucester Pike, Barrington, N. J.*

For more information circle **414** on inquiry card.

FOR THE SHOP

Tracers for Measuring Roughness in Deep Holes

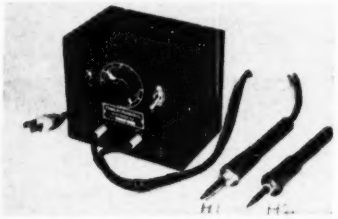
New line of six "Profilometer LE-type Tracers" is for taking surface roughness measurements in holes as small as 0.5 in. ID, as deep as 24 in., and from 1 to 75 microinches roughness. Tracers have an integral "Linkarm" or "Stiffarm," each available in three standard lengths for measur-

ing to maximum depths of 9, 18, and 24 in. Tracers with "Linkarm" are intended for operation by means of a motor-driven "Mototrace" but can be used for hand tracing if necessary. Tracers with "Stiffarm" are intended for manual operation but can be used with a "Mototrace." All can be used with any "Profilometer Amplimeter." —*Micrometrical Mfg. Co., 345 S. Main St., Ann Arbor, Mich.*

For more information circle **415** on inquiry card.

Soldering Unit

New "Model J-4" has been added to maker's line of 450-watt soldering units featuring adjustable heat con-

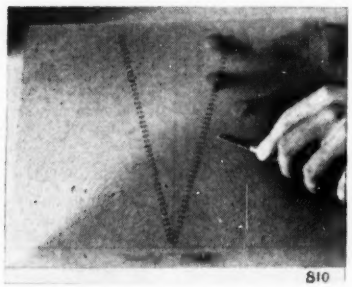


trol. It is available with an internal timer and a groundplate attachment. —*Vermaline Products Co., P. O. Box 222, Hawthorne, N. J.*

For more information circle **416** on inquiry card.

Plastic Chart-gages

New "Perma-Line" comparator charts represent successful development of a process for making permanent lines for plastic charts. Base material is Vinylite, a dimensionally



stable translucent plastic, on which makers process dense fine black lines which will not wear off, even by scraping with a pen-knife. All standard OGP chart-gages are available as "Perma-Line." Special charts or charts from customers' masters may be processed. Rectangular charts 20x24 in. maximum; round charts 30 in. diameter maximum. Note: "ESD Photo-Positive" plastic charts have been discontinued. — *Optical Gaging Products, Inc., 26 Forbes St., Rochester 11, N. Y.*

For more information circle **417** on inquiry card.

Cylindricality Gage

New type of air gage, for inspection of cylindrical parts such as automotive piston pins for outside diameter, cloverleaf, and taper, etc., is virtually wearproof: two cylindrical steel guide rails on each side of air ring can be rotated when sliding sur-

Design in Confidence

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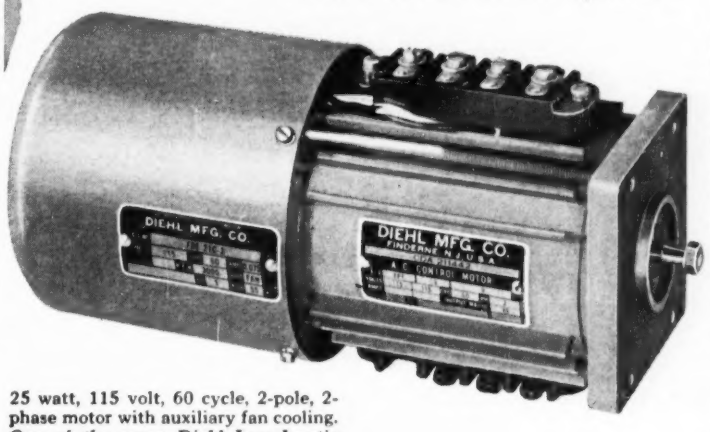
LOW INERTIA A.C. SERVO MOTORS...

. . . for Feedback Control Systems



25 watt, 115 volt, 60 cycle, 2-pole, 2-phase motor with auxiliary fan cooling. *One of the many Diehl Low Inertia A.C. Servo Motors available.*

CONSIDER THESE FEATURES

• High starting torque • Low rotor moment of inertia • Widest selection of ratings • Samples of many sizes available from stock • Engineering assistance offered when desired • Production quantities available in a reasonable time — at a reasonable price.

Diehl *originated* the Low Inertia A.C. Squirrel Cage Induction Motor — and Diehl's leadership in the field is still being maintained!

Originally designed for high-performance military servo systems, these motors are now being extensively used in the armed services with various types of electronic equipment. In industry, too, Diehl Servo Motors and components are being successfully applied in the design of automatic controls and a wide variety of other applications where optimum performance at reasonable cost is essential.

Meeting all appropriate JAN specifications, the two-phase servo motors can be supplied in sizes ranging from 2 watts to 750 watts mechanical output, 60 or 400 cycle supply. The smaller sizes include units with integrally-mounted tachometer generators for feedback. Many of the ratings are available with the control winding impedance specially designed for operation directly from the plates of electron tubes. Samples of most 60 cycle, and some 400 cycle, units are available for immediate shipment.

Our engineering staff will gladly help you select the motors best suited to your specific requirements. A request on your letterhead will bring you a copy of Technical Manual No. E-1153 describing Diehl Servo Motors and related equipment.

Other Available Components:

D.C. SERVO SETS • RESOLVERS

MINIATURE PERMANENT MAGNET D.C. MOTORS

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DIEHL MANUFACTURING COMPANY

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Atlanta Baltimore Boston Chicago Detroit New York Philadelphia Worcester

For more information circle **91** on inquiry card.

STABILITY

in RESISTOR APPLICATIONS

Stability refers to the ability of a resistor to retain its ohmic value during its entire useful life, and under varying conditions. Tolerance, on the other hand, is simply a statement of the ohmic limits within which the resistor was selected.

WELWYN Resistors are formed by a pure, homogeneous carbon film. Through the development of special manufacturing techniques, and through the use of post-manufacture processes and controls, Welwyn has succeeded in producing resistors of ± 1% stability. WELWYN High Stability Deposited Carbon Resistors are recommended wherever value drift is to be avoided.

For further Information and Test Data concerning . . .

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High Stability
DEPOSITED CARBON RESISTORS

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ONLY THE Servoscope®

HAS ALL THESE FEATURES

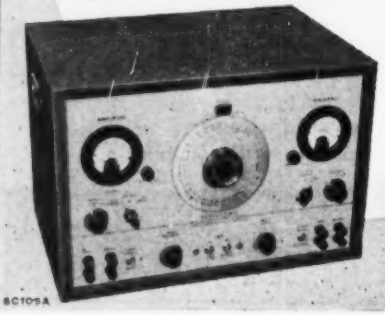
applicable to both AC carrier and DC servo systems

built-in low frequency sine wave generator for obtaining frequency response of DC servo systems

built-in electronic sweep with no sweep potentiometer to wear out and require replacement

dynamic frequency control range of 200 to 1

SERVOSCOPE is a versatile, time-saving test instrument for use in the development of all types of Servo-mechanisms and Process Controls.

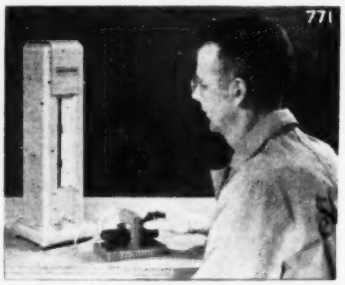


Write for bulletin giving complete specifications

SERVO CORPORATION OF AMERICA
NEW HYDE PARK, NEW YORK

For more information circle **93** on inquiry card.

NEW INSTRUMENTS

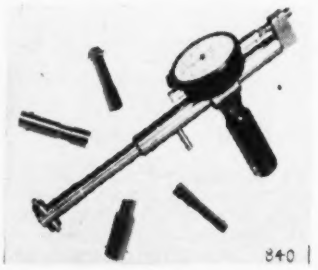


faces are worn. Thus, instead of scrapping gage or reworking guide rails, operator turns rails slightly and gets new locating surfaces of proper size.—*The Sheffield Corp., Dayton 1, Ohio.*

For more information circle **418** on inquiry card.

Dial Bore Gages

New dial bore gages feature interchangeable measuring heads: all



standard gage heads are interchangeable on one gage body.—*Rimat Tool Co., 21 West Dayton St., Pasadena 2, Calif.*

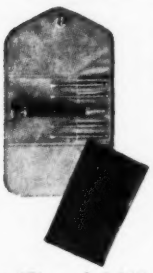
For more information circle **419** on inquiry card.

Induction Heating Unit

New "Model 5000 RF Heater," for soft soldering and silver brazing, incorporates a circuit and output transformer arrangement permitting extremely high no-load circulating currents in work coil. This causes a rapid heating of small hard-to-load-into parts; also permits use of single-turn or even half-turn work coils which operator (or work) can safely touch during operation. Unit is claimed to be ideally adapted to such operations as sealing of capacitors, relays, thermostats, crystals, resistors, transformers, etc., also suitable for soldering glass-to-metal terminals. Rated capacity is 5 kw. output.—*Radio Frequency Co., 44 Park St., Medfield, Mass.*

For more information circle **420** on inquiry card.

Instrument Screwdrivers



New "No. 989 Mini-Kit" screwdriver combination, for work on miniaturized equipment and on photographic, optical, and other instruments using tiny screws, consists of a swivel-top handle into which can be fitted any of four hardened steel blades (0.100, 0.080, 0.070 and 0.055 in.), all packed in a folding Vinylite case, 2 x 2.38 in. when closed.—*Insuline Corp. of America, 3602 35th Ave., Long Island City 1, N. Y.*

For more information circle **421** on inquiry card.

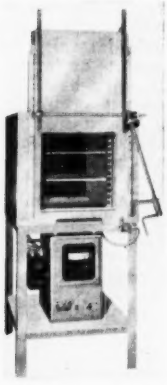
Dial Depth Gage

New "Model B-1500" dial-indicator depth gage is adjustable to 6.75 in. without changing measuring rods. Equipment includes one each of 4.25-

in., 6-in. and 8-in. straight rods and one 8-in. footed rod for gaging depth of grooves and recesses from face of bore.—*Reliant Industries, 4947 Firestone Blvd., South Gate, Calif.*

For more information circle **422** on inquiry card.

Electric Furnace



New "Automatic Recirculating Air Draw Furnace" features: (1) door which cannot drop: automatically self-locks itself at any position between closed and full open, preventing accidents to operator; (2) automatic air shutoff prevents burns to operator when inserting or removing materials; (3) guided air flow circulation for uniform heat treatment of specimen: rear-wall-mounted air impeller circulates air along both sides of furnace, between heater banks and radiant heat shields, towards door seal face, preventing any cold air inlet leakage; (4) power selector automatically regulates power input in proportion to operating tem-

1200°F..1500°F..2000°F!
CPI super high-temp thermal switch
• FASTER RESPONSE DUE TO LOWER THERMAL MASS
• MAINTAINS UNUSUALLY CLOSE TEMPERATURE CALIBRATION
• OPERATING TEMPERATURES TO 1700°F
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• CONSTRUCTED OF HIGH TEMPERATURE ALLOYS
• LIGHTWEIGHT (Approx. 6 ounces)
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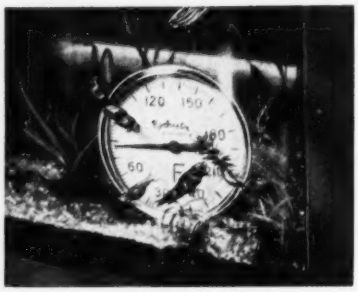
CPI Thermal Switches withstand any degree of overshoot or undershoot up to the ability of the metal to resist temperature rise. All welded construction eliminates moving parts. Particularly adapted to jet aircraft and turbine engines. Over a quarter century of thermal engineering experience to help solve your temperature control problems.
CONTROL PRODUCTS INC
324 SUSSEX STREET HARRISON · NEW JERSEY

For more information circle **94** on inquiry card.

Prevent thermometer fogging

No matter how long you dunk it, you can't cloud the accuracy of a Rochester dial thermometer.



THIS SUBMERSIBLE QUALITY is important to you. It means fast, easy temperature readings . . . without any danger of a foggy crystal causing inaccuracy. Rochester dial thermometers are assembled and hermetically sealed in a special humidity-controlled "dry" room. This eliminates any possibility of condensation inside the thermometer.

ALL STAINLESS STEEL CONSTRUCTION— All outer parts (except crystal) of Rochester dial thermometers are stainless steel. What's more, the case, stem and nut are fused into a single *corrosion-resistant* unit by an exclusive Rochester welding process.

EXCLUSIVE OUTSIDE RECALIBRATION— Rochester makes the *only* industrial thermometer that can be recalibrated from outside the case. If an extremely hard blow should knock it out of adjustment, you can have it back on the job in less than a minute . . . without taking the thermometer apart or breaking the hermetic seal.

You can order Rochester thermometers from one of our specialized instrument representatives listed in Sweet's Catalog. Or write direct for full details.

MILLIONS of Rochester dial thermometers are now delivering dependable service.

Rochester Manufacturing Company, Inc.
85 Rockwood St., Rochester 10, N. Y.

DIAL THERMOMETERS GAUGES AMMETERS

For more information circle **95** on inquiry card.

AUTOMATIC SHUT-OFF BUBBLE-TIGHT

***This* W. S. ROCKWELL Butterfly Valve**

was designed to seal off hydrocarbon vapors at 15 p.s.i. and 100°F. In actual tests with the Rockwell plastic lubricant seal, it gave air-tight shut-off to 50 p.s.i.

Call on us with your special valve problems.

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For more information circle **96** on inquiry card.

peratures; (5) test specimens not subjected to radiant heat; (6) Modella heater bank of low-watt density design for long service life. Temperature range: 300 to 1350 F. Indicating controller with Chromel-Alumel couple. All electrical devices U.L. approved. Two standard models, with 12 x 24 x 12 and 15 x 24 x 18 inside dimensions.—*Blue M Electric Co., 306-8 W. 69th St., Chicago 21, Ill.*

For more information circle **423** on inquiry card.

Granite Surface Plates

New surface plates are made of granite from Rock of Ages Quarry in Barre, Vermont, noted for exceptionally close-knit composition, flawless texture and color tone. Stone is said to be finished on head of grain "by an exclusive patented process."—*Bryant Chucking Grinder Co., Springfield, Vermont.*

For more information circle **424** on inquiry card.

Mechanical Comparator

New "Producto-Chek" light-weight mechanical comparator permits size settings to be made rapidly because of three adjustments: A coarse-adjustment lead screw on column; and two fine adjustments: a thumbscrew moves gaging head vertically and a lever moves dial scale laterally for minute zeroing movements or for setting scale off-zero to compensate for known errors in masters. Gaging head features double-reed amplifying system which eliminates wear and backlash and makes comparator self-compensating to temperature. Coil springs damp reeds and provide vibrationless indications without overswings. Measuring pressure of spindle is factory set, permitting operator to use both hands in high production checking operations. Column can be rotated on base, permitting instrument to be used with a surface plate or a master flat. New comparator is available in several ranges in both English and Metric calibrations. Gaging heads are interchangeable; may be purchased separately. Individual heads are readily adaptable to installation in multiple-gaging fixtures. Special spindle tips and a complete accessory kit are available for increasing diversity of application of comparator.—*The Do-ALL Company, Des Plaines, Illinois.*

For more information circle **425** on inquiry card.

VALVES

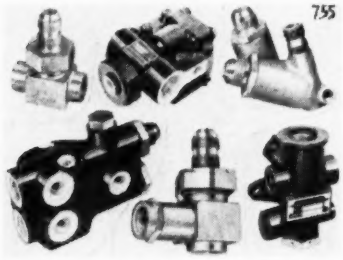
Diaphragm-motor Valves

New "Type D-53" Diaphragm Operated Control Valves" are intended for uses wherever it is desirable to control line flow (air, water, various chemicals and gases) by a pressure signal—an independent pressure applied to diaphragm. Feature is extremely high capacity — equal to normal 3/4 in. valves on market. Available in either 1/2 in. or 3/4 in. pipe size, normally-open or normally-closed. Maximum body pressure 250 psig.. diaphragm pressure 300 psig.—*A. W. Cash Valve Mfg. Corp., 666 E. Wabash Ave., Decatur, Ill.*

For more information circle **426** on inquiry card.

Aircraft Valves, Fittings

New valves and fittings have been developed for aircraft systems through which circulate oil and fuel

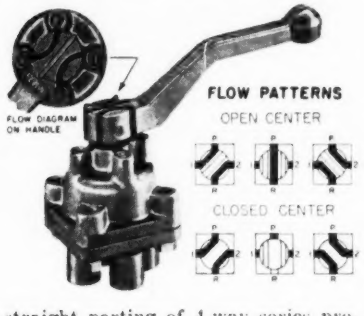


for engines, alcohol for de-icing equipment, oxygen for high-level flight, hydraulic fluids to operate doors and landing gear, as well as pneumatic systems.—*Kohler Co., High Street, Kohler, Wis.*

For more information circle **427** on inquiry card.

Oil-service Valves

New manual valves for 1500-psi. oil service utilize "Shear-Seal" principle accepted in 3000- and 6000-psi. service; feature extreme versatility;



straight porting of 4-way series provides for manifolding with standard tees in pressure and return ports; pedestal mounting; piping brought up straight may serve as operating

Now "Varec" offers a new Remote Reading ELECTRONIC TANK GAUGE RECEIVER...

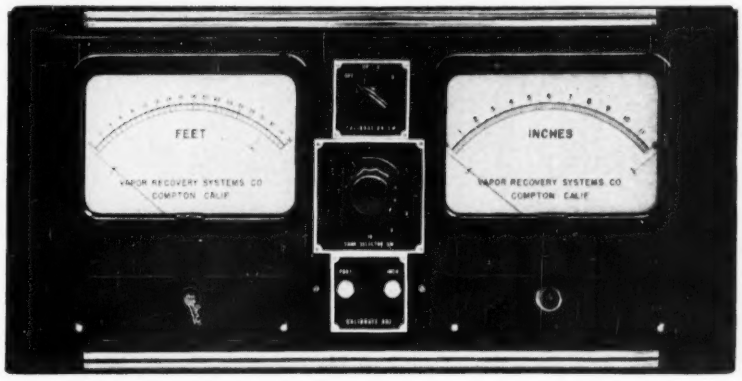


FIGURE NO. 8800 SERIES

...for 36-foot Range Tanks and Smaller

SPECIAL DESIGN—This new "Varec" RECEIVER has the many advantages of our larger range RECEIVERS, but is especially designed for tanks not exceeding 36 feet in height.

INCREASED EFFICIENCY—Reduces operation costs and increases plant efficiency. Provides accuracy, unusual speed, sensitivity.

EASY READING—Allows larger increments on foot-reading scale, permitting easy reading.

FLEXIBLE INSTALLATION—Designed in Standard, Relay or "On Gauge" types in cabinet or panel styles and can be used with electronic alarms or controls.

CHOICE OF CALIBRATION—English, Metric or special calibration as desired.

REASONABLE UNIT COST—With all its attractive features, this Figure Number 8800 SERIES RECEIVER has a very reasonable first cost.

Get all the details and illustrations in Bulletin CP-3004, just off the press.

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THE VAPOR RECOVERY SYSTEMS COMPANY
2820 N. Alameda Street, P. O. Box 231
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Company Name_____
Name_____ Title_____
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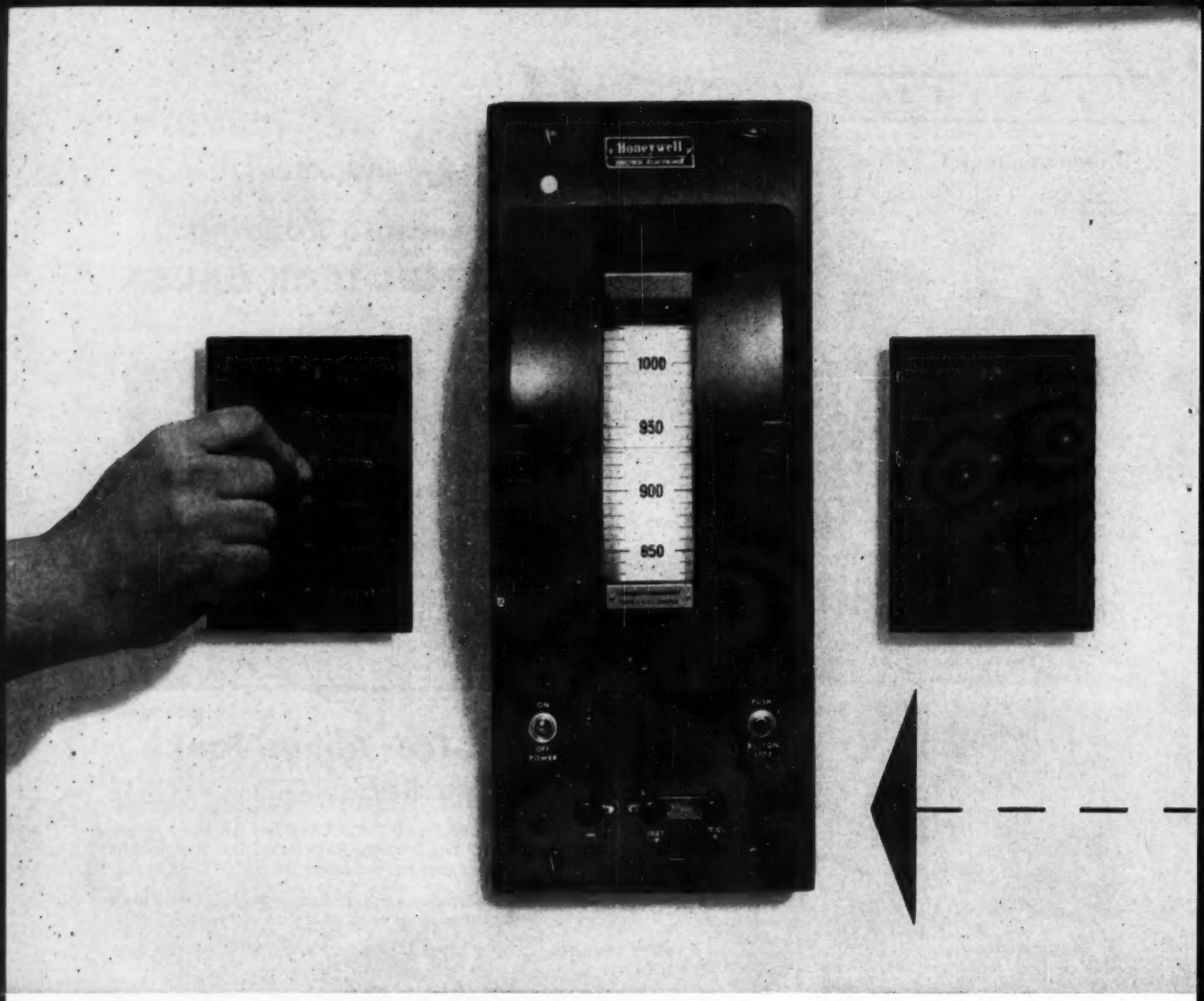
For more information circle **97** on inquiry card.



Look at these features!

compact case
approximately 6½ inches wide by 15⅜ inches high

easily-read drum scale
rotates vertically; graduated length 28⅝ inches provides big, legible scale divisions and numerals.

accurate hairline index
eliminates parallax errors, permits high readability.

fast measurement
full scale rotation in 4½ or 12 seconds for 60-cycle operation.

external key switches
can be located at the side of the indicator (as shown), below or above—wherever most convenient for the particular panel layout.

large number of points
additional key switch banks provide any desired number of temperature points. Legend plates facilitate identification.

high precision
calibrated accuracy is 0.2% of scale span.

variety of ranges
supplied for use with either thermocouples or resistance thermometers, in a selection of ranges applicable to power plant temperatures.

For more information circle 98 on inquiry card

Squeezed for panel space?

THIS NEW

Honeywell temperature indicator

needs no elbow room!

CROWDED PANELS are no problem for this new temperature instrument . . . the Vertical Scale Precision Indicator. Its slender, compact case makes it a natural for graphic panels—and a readily-inserted, space-saving member of conventional generator and turbine boards.

Basically, it's the same *ElectroniK* Precision Indicator which the power industry and many others have used and relied upon for many years. But, its outside appearance has changed: it's a completely new design that places the bulk of the instrument mechanism *behind* the panel . . . uses the valuable front-of-panel space primarily for the indicating scale.

Equipped with key switch banks, the Vertical Scale Precision Indicator offers a fast, convenient way to spot-check temperatures in bearings, pumps, hydraulic couplings, motors and other potential hot spots.

Your local Honeywell engineering representative will be glad to discuss how this new instrument can save space on the new panels which you may be planning. Call him today . . . he is as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4482 Wayne Ave., Philadelphia 44, Pa.

● **REFERENCE DATA: Write for new Bulletin No. 1541 on the Vertical Scale Precision Indicator.**

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls

For more information circle **98** on inquiry card

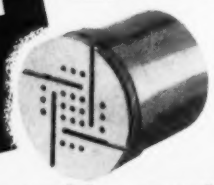
Check these features

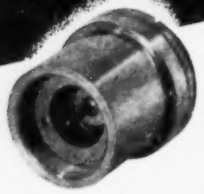
☐ UNIFORM DEPENDABLE RESPONSE

☐ EXCEPTIONAL CALIBRATION STABILITY

☐ LABORATORY AND INDUSTRY—PROVED PERFORMANCE

KELLOGG
Midget Condenser Microphone





for precision sound measurements and high quality recording

For more than sixteen years Kellogg Midget Condenser Microphones have been serving Industry and Research in sound measurements. Ruggedly constructed and humidity-proof, this microphone fully satisfies the exacting requirements of Laboratories for reliability and accuracy.

Users include government laboratories, universities, audio development laboratories, sound studios, and industrial plants manufacturing sound equipment.

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For more information circle **99** on inquiry card.

Pneumatic Weight Transmitters

FOR LINEAR CONVERSION OF WEIGHT INTO POUNDS PER SQUARE INCH AIR PRESSURE

A complete line of weight transmitters in single and multiple diaphragm construction with load capacities up to 23,000 pounds per diaphragm. Pneumatic tare balance for any portion of the total load on all models. All moving parts are enclosed totally. Complete weighing systems designed to your requirements.

WRITE FOR CATALOG

JOHN R. MONSELL
Manufacturing Engineer
Pitman, N. J.

For more information circle **100** on inquiry card.

stand; standard valves may be bracket or panel mounted. Valves range from 1/4 to 1 in. pipe size with full, unrestricted flow passage in all sizes. —*Barksdale Valves*, 5125 *Alcoa Avenue, Los Angeles* 58, *Calif.*

For more information circle **428** on inquiry card.

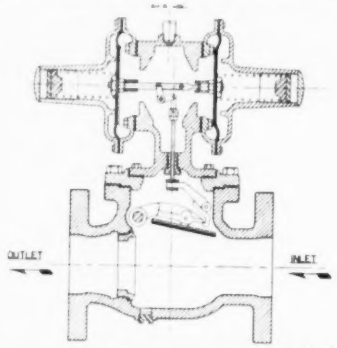
Bar-stock Needle Valves

New "270 Series needle valves are made of brass or 430F stainless steel bar stock in sizes from ⅛ to ½ in. NPT; straight line and angle pattern; choice of O-ring seal or conventional packing. (If helium leak-tested, O-ring style may be used for high-vacuum service.) Self-aligning spindle insures tight seating. Design permits repacking under pressure. Valves are available for instrument-panel mounting, with black plastic handwheel.—*Hoke, Inc.*, 231 *So. Dean St., Englewood, N. J.*

For more information circle **429** on inquiry card.

Automatic Shut-off Valves

New and improved basic models of automatic shut-off valves provide automatic shut-off in event of either in-

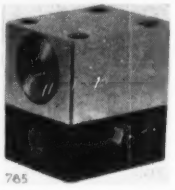


crease or decrease in pressure. Installation may be upstream or downstream (in relation to regulator), with or without static line control, for either high- or low-pressure application. Illustration shows "Model IDPSL" (closes on increase or decrease of pressure, static line control, low-pressure application).—*Security Valve Corp., P. O. Box* 1551, *Los Angeles, Calif.*

For more information circle **430** on inquiry card.

4-way Valves

New 4-way valves for operation of pneumatic and light hydraulic cylinders are of D-slide type, with port-exchanger slide operated by a double-acting cylinder in one series and by a spring return cylinder in another series. Durability: Nylon port exchanger has been service-tested to 50,000,000 cycles and found to be undamaged, as was hard-surfaced aluminum pilot cylinder assembly. Valves can be operated without lubri-



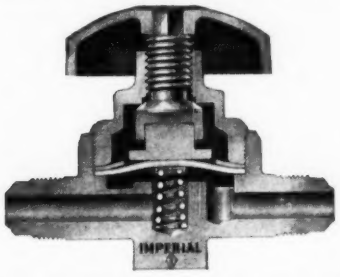
765

cation where application dictates oil-less operation. Valves operate on pressures from 3 to 200 psi. All can be operated manually or electrically by interchanging operating valve units. Maker also offers operating valves for these pilot valves, a line of speed controls, and reuseable fittings and hose. Dimensions 2.5x2.5x2 in.—*Airelectric Corp., Melrose Park, Illinois.*

For more information circle **431** on inquiry card.

Packless Instrument Valve

New "Red Head" packless shut-off valve, with solid Teflon diaphragm, is especially adapted for vacuum, instrumentation, etc. Soft seat is reported to provide positive shut-off

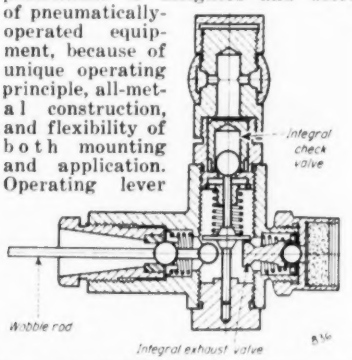


with finger-tip operation. Valve is recommended for pressures up to 300 psi.; holds ultra-high vacuum. Temperature range is –100 F. to 450 F. Available with 45-deg. flare or solder connections for tubing sizes from ¼ to ⅞ in. O.D., and ⅜ and ½ in. female pipe thread sizes. Both tube-to-tube straight-through valve, and angle valve with tube-to-pipe thread —*The Imperial Brass Mfg. Co.*, 1200 *W. Harrison St., Chicago 7, Ill.*

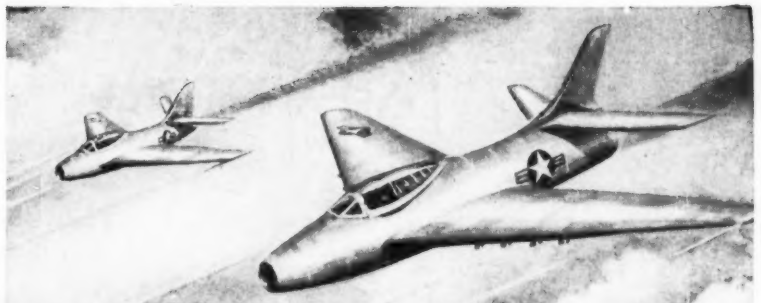
For more information circle **432** on inquiry card.

Wobble-rod Air Valve

New "Wobble-Rod Valve" with integral exhaust is said to offer new possibilities to designers and users of pneumatically-operated equipment, because of unique operating principle, all-metal construction, and flexibility of both mounting and application. Operating lever



is so swivelled that free end can move vertically, laterally, diagonally or in arcs and circles. Thus, valve can be actuated (manually, mechanically or electrically) by all manner of motions. It can be adapted to cyclic operation by passing it through an eccentric hole in a rotating disk or gear; and it can be spring-loaded to remain n-o. rather than n-c. Internal exhaust valve discharges air cylinder (or line or receiver) when valve closes, but can be eliminated where



Increased Combat Effectiveness *and* Operational Safety

In our front line aircraft, throughout the world, the philosophy of "packaged electronic functions" developed by Servomechanisms, Inc. to a high degree of refinement, insures:

- maximum reliability
- ease of maintenance
- complete interchangeability

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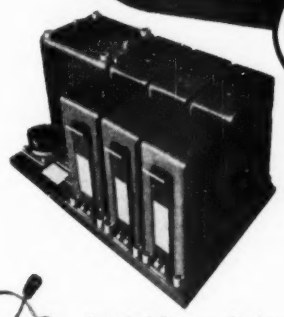
PACKAGED FUNCTIONAL COMPONENTS



A typical Servomechanisms, Inc. analog computer and companion transducer featuring plug-in components and pre-wired chassis—each electronic "building block" easily removable... simple to check and service.

For further information on specific applications write to Dept. CLO-5.

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For more information circle **101** on inquiry card.

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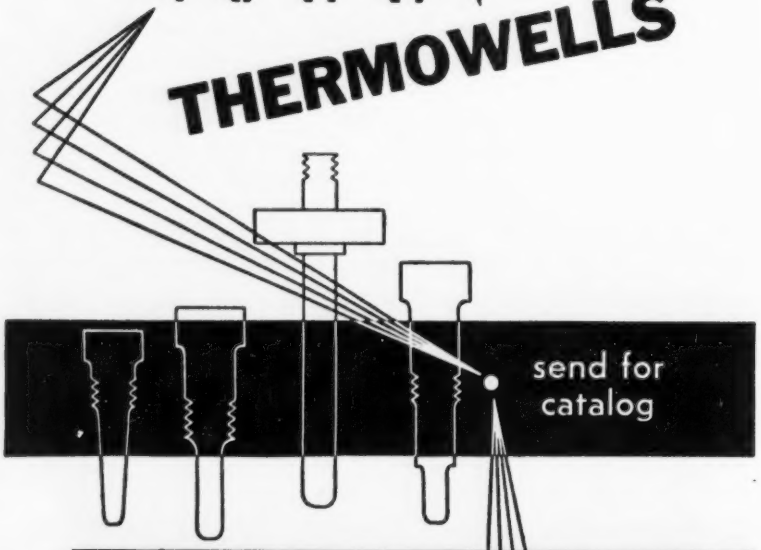

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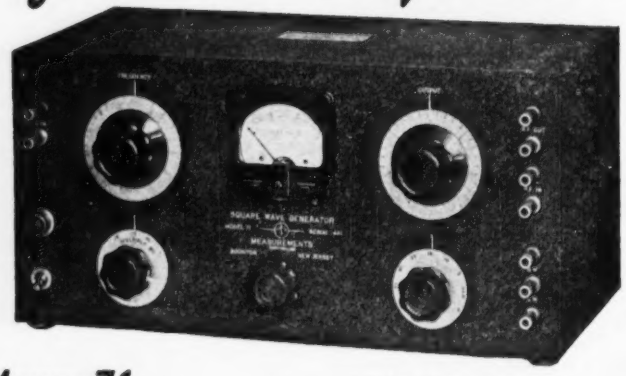
For more information circle **102** on inquiry card.

Square Wave Generator



MODEL 71

SPECIFICATIONS

FREQUENCY RANGE: 5 to 100,000 cycles.
WAVE SHAPE: Rise time less than 0.2 microseconds with negligible overshoot.
OUTPUT VOLTAGE: Step attenuator giving 75, 50, 25, 15, 10, 5 peak volts fixed and 0 to 2.5 volts continuously variable.
SYNCHRONIZING OUTPUT: 25 volts peak.
R. F. MODULATOR: 5 volts maximum carrier input. Translation gain is approximately unity—Output impedance is 600 ohms.
POWER SUPPLY: 117 volts, 50-60 cycles.
DIMENSIONS: 7" high x 15" wide x 7½" deep overall.

MANUFACTURERS OF
Standard Signal Generators
Pulse Generators
FM Signal Generators
Square Wave Generators
Vacuum Tube Voltmeters
UHF Radio Noise & Field Strength Meters
L-C-R Bridges
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Intermodulation Meters
TV & FM Test Equipment

MEASUREMENTS CORPORATION
BOONTON NEW JERSEY

For more information circle **103** on inquiry card.

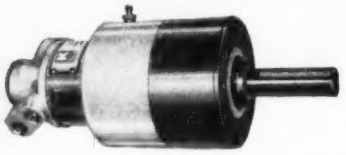
desirable to hold air-line pressures after valve has done its job. Another integral feature is a check valve (ahead of ball-and-seat) to prevent backsurge. Body design permits two valves to be assembled to provide 3-way, 4-way, tandem, or synchronized operations. Versality of installation results from: both right and left hand outlets, a double-ended inlet which can be rotated and clamped through 360 deg., and a drilled and tapped flange for panel or bracket mounting. Pressure limit 125 psig.; pipe size ¼ in.; weight 2¼ lbs.—*Pantex Mfg. Co., 521 Roosevelt Ave., Pawtucket, R. I.*

For more information circle **433** on inquiry card.

MECHANICAL COMPONENTS

Air Motors

New "70A Series" air motors feature an axial piston design that results in low air consumption; are instantly reversible; are available in

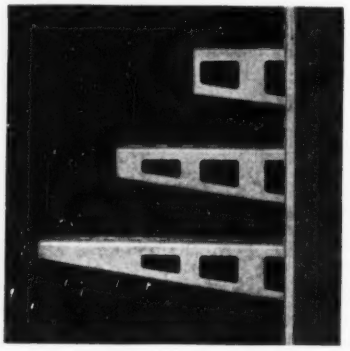


ratings from ½ to 2¾ hp, in twelve combinations of speed and torque. Air consumption from 21 cfm. in smallest to 83 cfm. in largest. Continuously-variable speed control, from zero to full, plus freedom from spark hazard, make new motors suited for process control (valve operation, etc.).—*Keller Tool Co., Grand Haven, Mich.*

For more information circle **434** on inquiry card.

Quick-mounting Bracket

New one-piece brackets for cable trough, instrument tubing trough, cable, pipe, conduit, etc., can be placed securely into slotted vertical channel



pieces by a twist of the wrist. No fasteners are required. New bracket is available in 3, 7, 13 and 19 in. lengths. (Greater lengths by use of extenders.)—*The Rakit Corp., 711 S. 50th St., Philadelphia 43, Pa.*

For more information circle **435** on inquiry card.

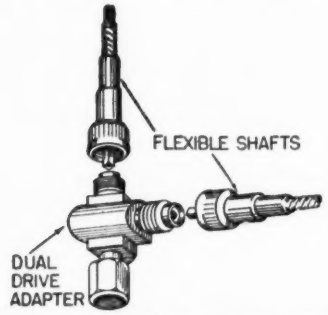
Flareless Tube Instrumentation Fittings

New line of flareless tube fittings, especially suited for use in instrumentation, do not require soldering or welding of joints. All that is needed to complete assembly of a joint is a wrench to tighten fitting nut. After tube is seated, nut is tightened to exert a wedging force on ferrule, which "bites" into outer surface of tube, forming a "shoulder" insuring a leakproof connection. Because cutting edge of ferrule is exposed, extent of bite into tube is readily visible if joint is disconnected for inspection. After inspection, fitting is reassembled by hand until ferrule is seated. An additional 1/6 to 1/3 turn of nut completes assembly. Complete fitting line includes male and female connectors, unions, male and female elbows, male and female run and outlet tees, union tees and crosses, nuts, ferrules and tube end reducers.—*The Parker Appliance Co.*, 17325 *Euclid Ave., Cleveland* 12, *Ohio.*

For more information circle **436** on inquiry card.

Flexible-shaft Dual Drive

New "Circle Ess" dual drive adapter is for use in conjunction with flexible-shaft drives where more than one unit is to be driven from one

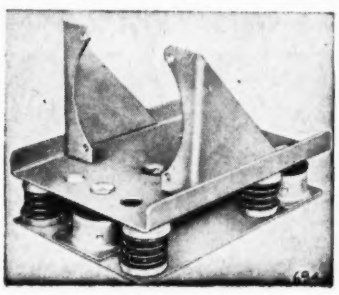


source, or to facilitate attaching flexible-shaft drives where limitations in space prevent direct connection without bending shaft excessively. Standard ⅝ x 18 threaded connections with 0.104 in. internal square drives; various ratios; left or right rotation; life-lubrication bearings; weight 4 oz.—*F. W. Stewart Mfg. Corp.*, 4311 *Ravenswood Ave., Chicago* 13, *Ill.*

For more information circle **437** on inquiry card.

Vibration Mounting Systems

New mounting systems permit reduction of weight, bulk, and cost in electronic equipment. Single-stage mount (illustrated) protects against



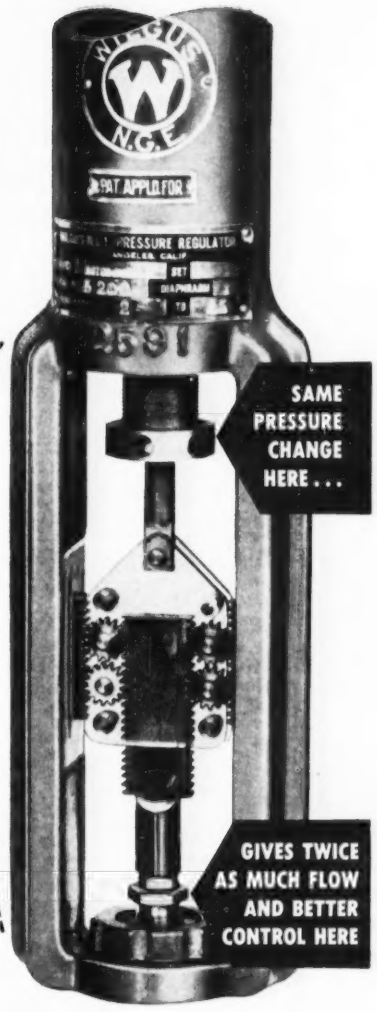
Gives you TWICE AS MUCH FLOW CONTROL

CUTS PRESSURE FLUCTUATION CHANGES IN HALF

THE THOMAS **MAGNA-STROKE*** PATENT APPLIED FOR*

A NEW DEVELOPMENT OF DESIGN AVAILABLE IN ALL N.G.E. *Wilgus* REGULATING VALVES for steam, liquids or gas

Magna-Stroke is a gear train working at a ratio of 2:1 giving twice the stroke at the inner valve as at the diaphram.



For Process Men Everywhere Who Want Better Control

Through the use of Magna-Stroke action double efficiency is received from regulating valves. Any increase or decrease in pressure to be secured by the opening and closing of the inner valve is done so at a ratio of two to one, since the action of the diaphram is doubled at the inner valve.

Liquid or vapors which are to be maintained automatically at a desired pressure within a close limit can be maintained at half the variation due to Magna-Stroke action of doubling the pressure effect.

Pilot Instrument Actuated Valves Work Twice As Fast

For example, if 30 seconds of time is required to actuate the valve, by pressure or temperature changes in the system, the Magna-Stroke valve will in turn respond in half the time, or 15 seconds.

Bonus Qualities Of N. G. E. Wilgus Regulating Valves Equipped With Thomas Magna-Stroke Action

Valves have smaller diaphragms thus effecting better control. When Magna-Stroke action is reversed, double the power is achieved. Just one more improvement of design which makes N. G. E. Wilgus Regulating Valves the leaders of the industry.

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I am interested in Magna-Stroke action as contained in
☐ Reducing Regulators ☐ Back Pressure Regulators ☐ Motor Valves

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For more information circle **104** on inquiry card.

When your problem involves drying air to obtain more efficient, dependable instrument operation, the Industrol Dynamic Dehumidifier offers you a practical low cost solution.

Dryers are offered with manual, semi-automatic or fully automatic control. Heat regeneration of desiccant is supplied by either electricity or steam.

An Industrol Dynamic Dehumidifier used in conjunction with the Industrol Centrisorb Filter is the ideal combination to give you the clean, dry air that spells trouble-free instrument operation.

Prove to yourself why more plant operating men are specifying Industrol. A qualified engineer is available to consult with you on your dryer problems.

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For more information circle 102 on inquiry card.

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STANDARD OF THE WORLD

for measurements

of pressure

of extreme accuracy

- √ A design for every application
- √ Accurate to 0.2% of scale or better
- √ Minimum hysteresis and creep
- √ Revolving dial zero adjustment
- √ "In place" bleeding of air
- √ Special designs for use with mercury

For the unusual pressure gauge application — where extreme accuracy and stability under continuous-use or other exacting conditions are essential — Heise Gauges can be specified with confidence.

Manufactured on special order only in ranges from 0-15 to 0-10,000 psi. Sizes: 8½", 12" and 16". Prices: $151.60 to $211.20. Write for catalog.

Heise Bourdon Tube Company, Inc.
Newtown, Connecticut

For more information circle 106 on inquiry card.

NEW INSTRUMENTS

vibration and shock for cylindrical instruments such as airspeed indicator. New system incorporates "Met-L-Flex" all-metal fabricated cushioning material.—*Robinson Aviation, Inc., Teterboro, N. J.*

For more information circle **438** on inquiry card.

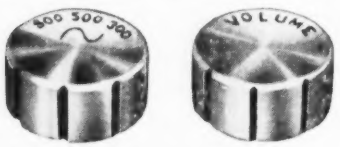
High-pressure Filters

New "Series 1H and 1HG" high-pressure liquid and gas filters have been added to "Micro-Klean" line. Standard units for operating pressures up to 1000 psi; special units for higher pressures. Guaranteed degrees of filtration are 10, 25, 50 and 75 microns. Maximum capacity for liquid at 150 SSU, 2-psi. pressure drop and 50 micron degree of filtration is 15 gpm. For gases at 1000 psig., 2-psi. pressure drop and 25 micron degree of filtration, maximum capacity is 200 scfm. (free air).—*Cuno Engineering Corp., Meriden, Conn.*

For more information circle **439** on inquiry card.

Custom-made Knobs

New hand-machined and hand-engraved metal knobs for electronic and other industrial equipment are available in five diameters from 1 in. to



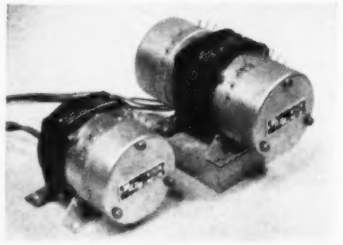
2.5 in. Any word or inscription can be engraved with any recessed color combination. Face of knob has a circular satin machine finish; screw type mountings are provided for round or flat shafts to fit standard 0.25-in. shafts.—*Pacific Transducer Corp., 11921 W. Pico Blvd., Los Angeles 64, Calif.*

For more information circle **440** on inquiry card.

ELECTROMECHANICAL COMPONENTS

Synchronous Choppers

New "Instrument Type De-Ac. Synchronous Choppers" are precision-motor-driven commutator-type switching devices for commutation of a-c. and d-c. signals in synchronism with 60-cycle supplies; have 5000-10,000-hour life in normal applications; can be supplied with 2-p. or 4-p. d-t. switches at one end and shaft exten-



sion at other end to drive mechanical or optical equipment that must be properly phased to electrical signals. —*Instrument Development Labs., 163 Highland Ave., Needham Heights, Mass.*

For more information circle **441** on inquiry card.

Panel-mounting Test Points

New "Klipzon Points for Panel Mounting" are for production testing or life testing of germanium diodes, transistors, resistors, capacitors, printed circuits and similar components.—*United Technical Labs., Morristown, N. J.*

For more information circle **442** on inquiry card.

Test Clip

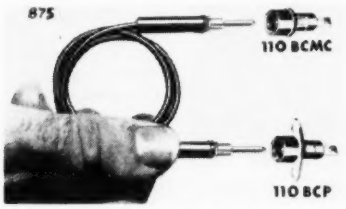
New fully-insulated alligator clip facilitates testing of live circuits in electrical equipment. Spring-loaded

jaws, actuated by a thumb button in body of clip, hold firmly on conductors up to 0.25 in. diam. Connection to clip is made with standard banana plugs.—*Insuline Corp., of America, 3602-35th Ave., Long Island City 1, N. Y.*

For more information circle **443** on inquiry card.

Test Jacks and Prods

New "Mini-Test" make critical internal voltage points in any electronic equipment instantly accessible for readings at front panel; require only



a small mounting hole and less than 1 in. behind panel; have molded insulating bodies surrounding their contact; 8,000-volt rms. breakdown to ground; exposed front panel mounting ratings of 500 to 2,500 volt rms. For use with new jacks, two new injection-molded test prods: "111-IL" single lead and "111-IL2" for jumper or patch work; both insulated by low-loss polyethylene.—*Alden Products Co. 117 North Main Street, Brockton 64, Mass.*

For more information circle **444** on inquiry card.

Connector Kit

New kit for micro-miniature connectors and cables is fully equipped for prototype construction with a specially-designed self-assembly hand

graphic recording simplified by the new XY plotter and recorder

Desk or rack mounted. Fits standard RCA or RMA rack mountings. Takes standard 11" x 16½" or 8½" x 11" graph paper. 4-Quadrant operation. Zero Offset and Scale Expansion adjustable on both axes. Unique ink pressure regulator assures trouble-free pen operation. Unit is self-contained with servo amplifiers, power supply and control circuits—mechanically rugged, attractively designed. Accurate to ±0.1% full scale, power consumption 150 watts. Write for catalog information.

For discrete point plotting or continuous-trace recordings on standard graph paper, Librascope produces a two coordinate portable recording instrument called the X-Y Plotter and Recorder. This unit is noteworthy for rapidity and accuracy of performance and is applicable to a great variety of data reduction operations.

If you desire the challenge of advanced design fields and qualify in education and experience, write to Dick Hastings, Personnel Director.

See this unit in operation at the Eastern Joint Computer Conference & Exhibition, Hotel Statler, Washington, D.C., December 8-9-10.

For more information circle **107** on inquiry card.

FOR DYNAMIC PRESSURES

NO OTHER Pressure-Measuring Device COMPARES with

Electro ELECTRONIC EQUIPMENT Pressuregraph

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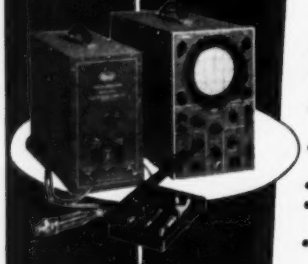

- Measures dynamic pressures.
- Drift stabilized.
- Temperature stabilized.
- Linear output for unit pressure change.
- One pick-up for all pressures.
- Balanced output for driving DC recorders.
- No need for pre-amplifiers to drive recorders or oscillographs.
- Simple operation.
- Records pressure transients as short as 50 micro-seconds.
- Can be water-cooled for temperatures exceeding 1000° F.
- Auxiliary Synchro-Marker adds 2 channels (timing and positioning) on pressure curve.
- Up to 200 feet of pick-up cable can be used.
- Flush-head type pick-up available . . . stops cavity effects.
- Auxiliary pick-up standard assures correct adjustment for all diaphragms.
- Time proved by internationally known industrial concerns, universities and research laboratories.
- Reasonably priced.

Bulletin listing varied applications and specifications on request.

EPL Field Engineers Throughout the Country Available to Help Solve Your Pressure Problems.

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For more information circle **109** on inquiry card.

NEW INSTRUMENTS

tool; a "blow-up" illustrated manual, 30 connectors, "Microdot" adapters to BNC fittings; and 50 feet of 50-ohm coaxial cable.—*Microdot Div., Felts Corp., 1826 Fremont Ave., South Pasadena, Calif.*

For more information circle **445** on inquiry card.

Shaded-pole Motor

New "Model 3000" EMC shaded-pole motor for gear-motor applications, available in several variations with or without gear units, is said to be the first motor of its type to be completely housed in an aluminum motor housing. Gear ratios up to 2000:1 are available. Output up to 120 in.-lbs. or without gear unit ratings to 1/200 hp. at 3400 rpm. Other features include thermal overload protector (optional), and fan (optional). —*Howard Industries, Inc., Racine, Wis.*

For more information circle **446** on inquiry card.

Integrating-device Motor

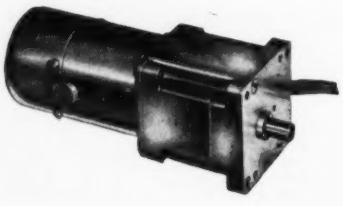
New "Model 120 Integrating Motor," designed for operation on minute power sources such as photocells,

finds principal applications in guided-missile control systems or aircraft autopilots; is claimed to "dynamically outperform any known motor within its power classification." It has an acceleration constant of 0.003 sec. and torque-to-inertia ratios of 10^4 to 10^6 sec.$^{-2}$; power sensitivity 0.1 microwatt; current sensitivity 0.02 ma.; minimum starting voltage 0.005v. Present model is fitted with a precision gear train and a 5-watt voltage-dividing resistor (special output mechanisms built and installed to customer requirements). Length 3.37 in., diam. 2.5 in.; weight 1.3 lb. —*Summers Gyroscope Co., Santa Monica, Calif.*

For more information circle **447** on inquiry card.

Rotary Power Unit

New "Series 181 Rotary Actuator," light-weight unit of comparatively simple design, provides rotary output up to 15 watts at speeds from 16 to 195 rpm. (maximum permissible torque 25 lb.-in.); features an integral slipping-gear-type torque-limiting device which prohibits unit damage through inadvertent overloading or jamming. Unit is driven by maker's standard 26-v.dc. motor including a



brake, or combination clutch-brake, to aid in accurate positioning. Optional: radio noise filter, motor thermal protection, end position limit switches, output shaft configuration, speed and torque (within range mentioned above) and AN connector.—*Grand Rapids Div., Lear, Inc.*, 110 *Ionia Ave., N. W., Grand Rapids 2, Mich.*

For more information circle **448** on inquiry card

Right Angle Connector

New "No. B2897 Pulse Type Connector" right-angle adapter for use where space is limited, mates with standard UG 182 A/U receptacle and a male panel-mounted receptacle of same series. Size approx. 2 27/32 x 3¼-in. Designed for 5,000-v. peak at 50,000 ft. altitude: produced to surpass rigid military specs.—*H. H. Buggie, Inc., 726 Stanton St., Toledo 4, Ohio.*

For more information circle **449** on inquiry card

Airborne-devices Relay

New "Type M" 6p-dt. hermetically-sealed relay weighs 3.5 oz.; has a volume of 1.5 cu. in.; meets MIL-R-5757 A and B specs for airborne electronic equipment. Shock resistance 40 *G* for 0.01 second under any conditions without malfunctioning; temperature ranges of −55 C. to 85 C. and −65 C to 125 C.; maximum pull-in voltage of 18 at max. rated temperature; max. drop-out voltage of 13 at max. rated temperature; and minimum life expectancy of 1,000,000 operations. Standard contact ratings are 2 amp. resistive for 100,000 operations; 8 amp. overload resistive for 100 cps. at 26.5 v.dc. Contact loads of 100 ma. at 400 v.dc. for over 500,000 operations have been successfully handled by two contacts in series.—*Union Switch & Signal, Div., Westinghouse Air Brake Co., Pittsburgh 18, Pa.*

For more information circle **450** on inquiry card

ELECTRICAL AND ELECTRONIC COMPONENTS

Magnetic Amplifiers

New miniaturized magnetic amplifiers feature extremely high power handling capability for their size and weight. This is made possible by special core materials, winding techniques, and mountings, coupled with use of high-frequency a-c. power:

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2000 and 4000 cps. Unit illustrated, "Model MA-48," weighs 3 oz.; its power output is conservatively rated at 25 watts.—*D & R, Ltd., 402 E. Gutierrez St., Santa Barbara, Calif.*

For more information circle **451** on inquiry card.

Instrument Amplifier

New "Model 2607" amplifier is said to represent an advancement in subminiaturization combined with rugged design, accomplished by using subminiaturized components and etched circuit wiring. It provides an input impedance of over 150 megohms for piezoelectric, capacitive, and other types of measuring elements. Selectable gain ratios of 10, 30, or 100 allow for a full 5-volt output from an acceleration pickup generating 10 mv./*G*. when measuring 5 *G*. of acceleration or vibration. Size 2.75 x 4.4 x 0.75 in. Ruggedized type WA tubes and shock-resistant construction provide 3 percent high gain stability under varying supply and ambient conditions.—*Endevco Corp., 689 S. Fair Oaks Avenue, Pasadena 2, Calif.*

For more information circle **452** on inquiry card.

Miniature Resistor

New "Type 1101 Sub-Miniature Resistor," for space-saver applications in military equipment requirements, measures only ¼ in. diameter and 13/32 in. long, can be wound in all values up to 175,000 ohms. Resistance tolerances to 0.1 percent are available with power rating of 0.1 watt.—*The Daven Co., 191 Central Ave., Newark 4, N. J.*

For more information circle **453** on inquiry card.

Miniature Resistor

New deposited-carbon "Transistor Resistor" of ⅛ watt rating is available in resistance range from 4 to 250,000 ohms; maximum voltage 250.

Makers emphasize that deposited carbon manufacturing process makes possible maximum stability regardless of resistance value tolerance: 1, 5 and 10 percent being equally stable. —*Electra Mfg. Co., 2537 Madison, Kansas City, Mo.*

For more information circle **454** on inquiry card.

Sealed Resistors

New "Type PM" resistors offer positive hermetic sealing, immunity to high temperatures, moisture and salt spray; are designed to exceed MILR-93A specs. They are imbedded in an exclusive high-temperature compound having same T.C. of expansion as wire and coil forms. Units are available in six body sizes with various terminal arrangements; can be supplied with windings of Nichrome Karma or Manganin alloys; resistance values to over 6 megohms. All types are non-inductively wound. —*Instrument Resistors Co., 1036 Commerce Ave., Union, N. J.*

For more information circle **455** on inquiry card.

Variable Inductance Kit

New Variable Inductance Kit consists of eight permeability tuned coils, calibrated within 5 percent limits. A curve sheet indicating inductance values is supplied for each coil. —*United Technical Labs., Morristown, N. J.*

For more information circle **456** on inquiry card.

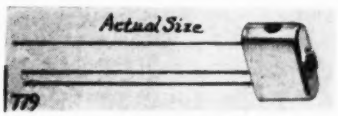
Metalized-ceramic Feed-through Insulators

New vacuum-tight ceramic terminals and feed-through insulators feature brazing and service temperatures up to 1400 F. Sizes from 7/32 in. to ½ in. diameter; voltage ratings from 3400 to 12,000 v. Metalized surfaces are suitable for brazing and hard-soldering; if desirable, maker can pre-assemble insulators in end-plates or headers to customer's specifications.—*Advanced Vacuum Products, 22 Liberty St., Stamford, Conn.*

For more information circle **457** on inquiry card.

Photo Transistor

New "Type X-25 Germanium NPN Junction Photo Transistor," said to be the first commercially-available amplifying photo transistor, may be

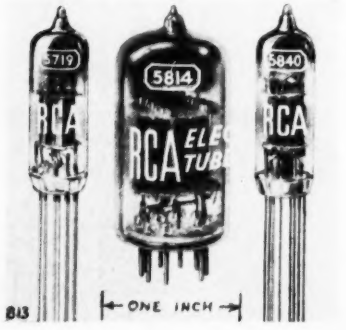


described as a light-sensitive device with an incorporated amplifier. It has obvious applications in automatic punch card machines, automatic dimmers for automobiles and automatic brilliance controls on TV receivers. It is an *n-p-n* junction photosensitive transistor with sufficient power output to operate a relay. Maximum operating power is 60 milliwatts and maximum non-destructive power 400 milliwatts.—*Transistor Products, Inc., Snow and Union Sts., Boston 35, Mass.*

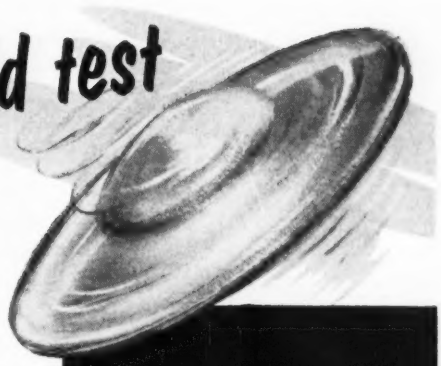
For more information circle **458** on inquiry card.

Electron Tubes

New electron tubes suitable for instrumentation uses include: (1) "5719," a subminiature "premium" high-mu triode giving dependable performance under shock and vibration: in audio service as a resistance-coupled amplifier, it is capable of providing high voltage gain. (2)



If you could test a Flying Saucer..



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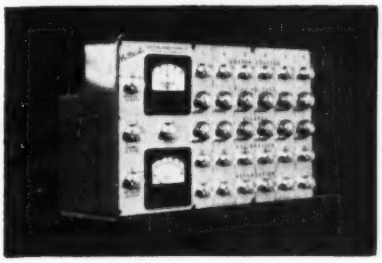
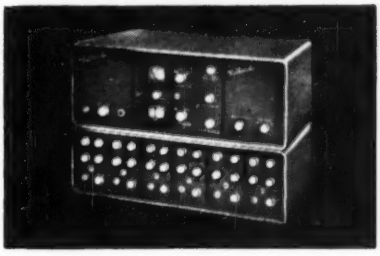
New Heiland "82-6" BRIDGE BALANCE and Strain Indicator...



The Heiland "82-6" Bridge Balance provides a simple, accurate means of calibrating static and dynamic output from resistive type transducers or strain gages, before feeding these phenomena into a recording oscillograph. Static and slowly changing phenomena may be read directly on the highly sensitive output meter.

Write or wire for features and specifications.

New Heiland Model 119 AMPLIFIER SYSTEM



A complete measuring system including Oscillograph, Amplifier and Bridge Balance units. Can be conveniently installed in a standard 19-inch relay rack, or placed side by side on table with equal ease and simplicity. Relay rack mounts are available for all units. Removable shock mount bases are available for installation in moving vehicles, aircraft, etc., where shocks and accelerations are encountered. Housed in a rugged, yet lightweight cast aluminum case finished in attractive silver-gray gloss enamel.

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NEW INSTRUMENTS

"5814," a 9-pin miniature "premium" medium-mu twin triode for use in many instruments, and in industrial control devices: dependable performance under shock and vibration (3) "5840," a subminiature "premium" sharp-cutoff pentode for use primarily as a broad-band rf. or if. amplifier in mobile and aircraft receivers; meets military requirements.—*Tube Dep't. Radio Corp. of America, Harrison, N. J.*

For more information circle **459** on inquiry card.

Temperature-limited Diodes

New "5DC-5" and "5DC-5M" tubes have cathode voltage 5.6 ac/dc., cathode current 55-75 ma.; plate voltage 500, plate current 0.450-0.575 ma. "5DC-5" has T9F1 bulb and #8537 8-pin intermediate octal base; "5DC-5M" has T5-1/2 bulb and T5-1/2 7-pin miniature button base. These diodes have temperature-limited emission characteristics, where anode current is a direct function of filament voltage. Small changes in filament voltage result in relatively large changes in anode current. Use of pure tungsten filament maintains specified ratings throughout normal life of tube.—*Thermosen, Inc.*, 361 *West Main St., Stamford, Conn.*

For more information circle **460** on inquiry card.

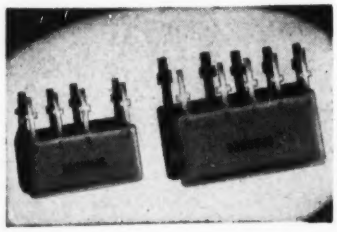
TV Distribution-system Signal-strength Controller

New "Model 442 Automatic Level Control" maintains proper signal strengths in a TV distribution system. (Without ALC, if signal level of one or more channels increases appreciably, amplifier is driven beyond its region of linear operation, and picture on one channel tends to "spill-over" or cross-modulate, causing poor picture quality on other channels.) System maintenance is reduced when "Model 442" is used. Deterioration of cable and variation in amplifier performance due to tube aging are also automatically corrected.—*Spencer-Kennedy Labs., Inc.*, 186 *Massachusetts Ave., Cambridge* 39, *Mass.*

For more information circle **461** on inquiry card.

Printed Circuits

New "Bulplate" *RC* networks, for use in assembly of printed circuits, have dagger terminals—particularly convenient where wiring is used on both sides of a board. "Bulplates" with this type of terminal can be positioned accurately to permit automatic assembly on circuit boards with plate supporting itself during auto-

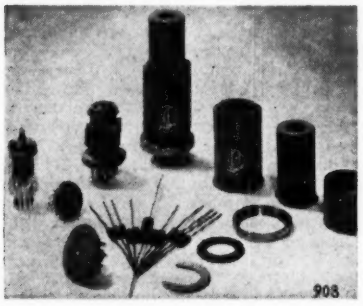


matic dip soldering operations. Various types of standard integrators, diodes, filters, decoupling, output, and coupling networks are available.—*Sprague Electric Co.*, 199 *Marshall St., North Adams, Mass.*

For more information circle **462** on inquiry card

Plug-in Circuits

New models of maker's plug-in electronic circuits are available with a case which may be completely taken apart without tools, to facilitate

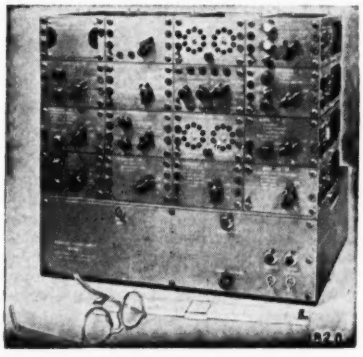


visual inspection; retain all of their shock and vibration resistance advantages without dipping or potting in wax or resinous compounds; are moisture- and fungus-proofed. Circuits include amplifiers (pulse d-c., a-f.), delay circuits, multi-vibrators, gate circuits (diode, pulse, sine-wave), phantastrons, voltage regulators, squaring circuits, "And" and "Or" circuits, delay lines, networks, crystal oscillators, and thyratron ring counters. Other circuits custom-designed.—*Plug-In Div., Electronic Engineering Co. of Calif.*, 180 *S. Alvarado St., Los Angeles* 57, *Calif.*

For more information circle **463** on inquiry card.

Unitized Pulse Circuits

New "Modular System of Digital Pulse Units," said to be "a basic new electronic tool of great flexibility in design and use of pulse methods for information transmission, storage and computation," consists of sixteen electrically and mechanically compatible "Modulars" which perform all basic functions of digital pulse operations, such as gating, pulse forming, counting, coincidence marking, etc., as well as amplification, signal inversion and impedance matching. Unit size 2.75 x 4.5 x 9 in. Since each unit performs a multiplicity of independent functions selectively, a complete system consisting of 16 units and a regulated



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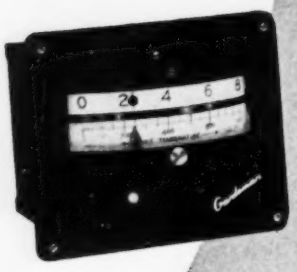

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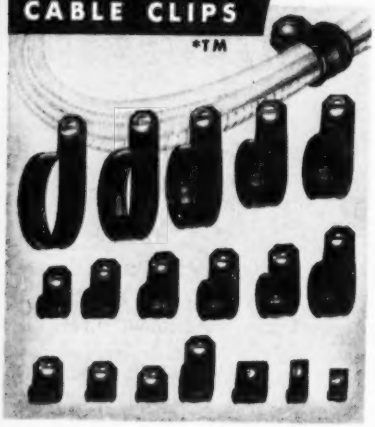

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NEW INSTRUMENTS

power supply has a capability of 72 separate functions with as many as 31 functions simultaneously available. Simple digital instruments can be quickly patched up.—*Audio Products Corp., 2265 Westwood Blvd., Los Angeles, Calif.*

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Selenium Rectifiers

New "CR Series" of miniaturized selenium rectifiers has been developed for use in production of TV boosters and UHF converters for original equipment manufacturers but, since these units are small, they are suitable as replacements in servicing boosters, converters, and other electronic equipment requiring relatively low current drain. New rectifiers consist of a number of cells assembled within a cylindrical aluminum tubing and provided with pigtail copper leads. Smallest unit, 0.5 in. diam. and 0.6 in. long; largest unit, 0.75 in. diam. and 0.6 in. long.—*Selenium Rectifier Corp., El Segundo, Calif.*

For more information circle **465** on inquiry card.

Diffused-junction Germanium Rectifiers

New "1N151, 1N152 and 1N153," are added to maker's line of diffused-junction germanium rectifiers; are hermetically-sealed and equipped with cooling fins; have peak inverse voltage ratings of 100, 200 and 300 volts respectively. All have 0.5-amp. output ratings, with an efficiency at these ratings of more than 98 percent. Ambient temperature rating is 55 C.—*General Electric Co., Schenectady 5, N. Y.*

For more information circle **466** on inquiry card.

Glass-cloth Laminates

New "Epoglas" laminate of epoxy-resin and glass-cloth is available in two forms: (1) copper-clad on one or both sides, ready for etching; or (2) unclad, for use in terminal boards or as a base for plated and printed circuits. Sheets are 24 x 36 in. and thicknesses from 0.003 in. through 0.500 in. Deliveries will be expedited by priority certificates.—*Plastilight, Inc., 81 Canal St., Stamford, Conn.*

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Wideband Directional Couplers

Four new wideband directional couplers for power, impedance or match measurements between 30 and 1500 Mc. have broad power and frequency ranges permitting their use on a wide variety of laboratory measuring problems, including coefficient of reflection or SWR, power in load, or dynamic match; are also practical as components in VHF-UHF transmitters; may be used with either coaxial lines or with lumped linear passive networks.—*Sierra Electronics Corp., 1050 Brittan Ave., San Carlos, Calif.*

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Tantalum Capacitor

New tantalum capacitor, believed to be the smallest high-capacity unit ever designed for low-voltage d-c. applications and intended as a companion for the transistor, is 5/16 in. long and ¼ in. diam. Features include advantage in size per volt microfarad over most other electrolytics, long shelf and operating life, wide temperature range, and low leakage current. Unit is sealed against leakage or contamination, utilizes a non-acid electrolyte, is available in ratings from 2 to 16 v., 4 to 0.7 uf. respectively. A larger capacitor, 0.5 in. long, with similar characteristics and same voltage range, but with 8 to 1.5 uf., has also been announced.—*Capacitor Dep't, General Electric Co., Hudson Falls, N. Y.*

For more information circle **469** on inquiry card.

Steatite-cased Paper Tubular Capacitors

New "Budroc" steatite-cased paper tubular capacitor has extraordinary temperature and humidity resistance. It is of non-inductive construction and housed in a ceramic (steatite) tube with Polykane end seals. Units rated up to 400 vdcw. will withstand temperatures from –40 to 90 C.; units rated 600 vdcw. and above will withstand operating temperatures of –55 C. to 100 C. All units are capable of withstanding more than 250 hours of exposure to 95 percent relative humidity at 40 C. They also withstand life test of 150 percent of rated dc. voltage at applicable high test temperature for 250 hours. Units are available in wide ranges of capacitances and voltage ratings.—*Industrial Div., Cornell-Dubilier Electric Corp., South Plainfield, N. J.*

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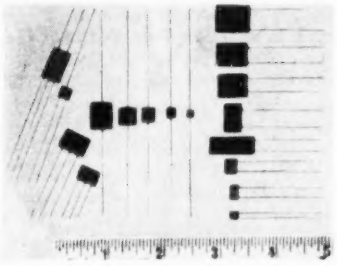
Wide-temperature-range Subminiature Capacitors

New "HT Series" high-capacitance subminiature ceramic capacitors maintain their capacitance over an extended temperature range: between



–40 C. and 125 C., it will not fall below 65 percent of room-temperature value. Units may be obtained as small as 1/8 in. square with thickness 0.090 in. maximum for a value of 350 mmf GMV (guaranteed minimum value at room temperature) rated 200 WVDC. Units are usually made to customer's dimensional requirements, square or rectangular, with radial or axial leads.—*Mucon Corp., 9 St. Francis St., Newark, N. J.*

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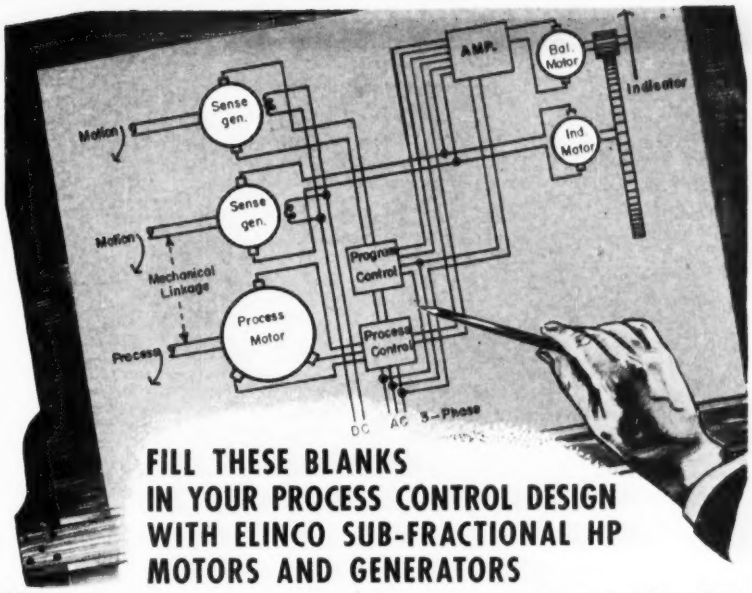

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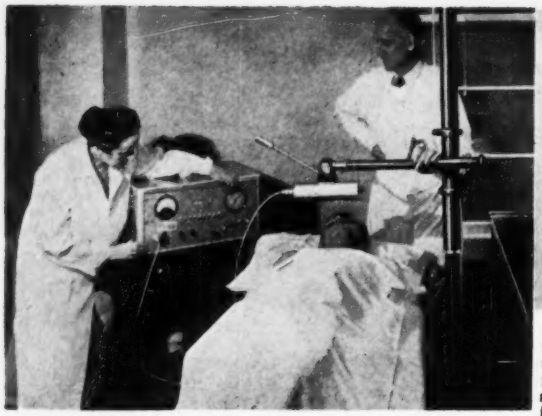
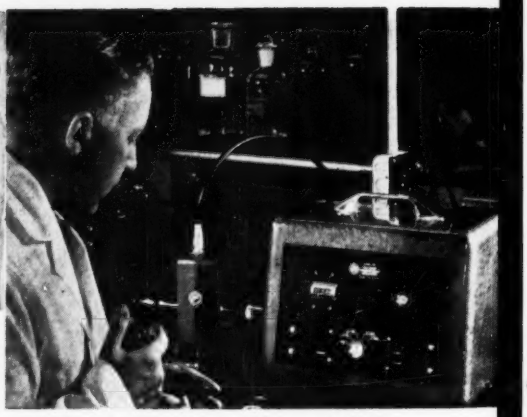


Geiger-Mueller counter tube (above patient) being used with a scaler-type indicator in treatment of hyperthyroidism. (Photo courtesy Radiation Counter Laboratories, Inc.)

Pulse integration system for measurement of fast-neutron dosage, used with proportional counter. Integrator weights pulses according to their amplitude and then adds total output to give integrated pulse current. (Photo courtesy Radioactive Products, Inc.)



Small scaler using glow-transfer-type indicator for use with Gieger-Mueller counters. (Photo courtesy Nuclear Instrument & Chemical Corp.)

Nuclear Reactors for Industry and Research

III. RADIATION MEASUREMENT

By Dr. ERNEST H. WAKEFIELD*

Basic to all work on or near nuclear reactors is knowledge of the types of nuclear radiations, and of the instruments by which the radiations are detected and measured.

NUCLEAR REACTORS are sources of nuclear radiations. There are six different types of commonly used nuclear radiations—alpha particles, beta particles, positrons, gamma rays, protons and neutrons. Each of these radiations is detected directly or indirectly by the ionization which it causes in passing through a medium, such as a gas.

Alpha particles are fast-moving helium nuclei. This radiation is given off by several elements, among them plutonium, one of the components of the atomic bomb. Alpha radiation has typically a path-length in air of from two to five centimeters; hence it can be stopped by even a sheet of paper. Alpha particles are emitted in a monochromatic or line spectrum, and are characterized by a unique range.

In contrast, *beta radiation*, which is the name given to fast-moving electrons emitted from radioactive isotopes, is emitted in a continuous spectrum of energies up to a maximum value. Beta particles have a typical path-length in air from a few millimeters to perhaps a few tens of meters. Cosmic-ray electrons, however, may have much greater path lengths. Beta particles generally can be shielded against by a thin layer of metal.

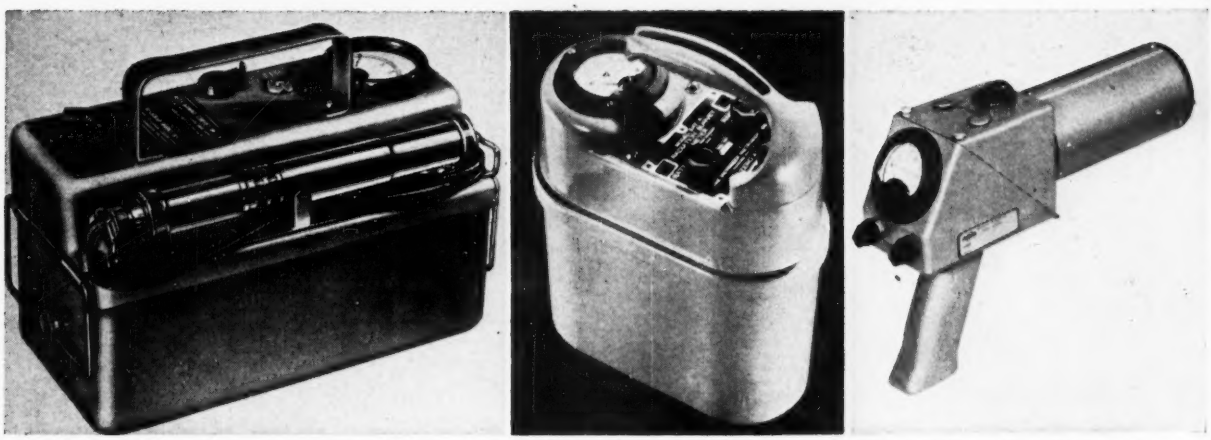
Positrons, which are positive electrons, may have an extremely short life because they combine readily with free negative electrons (with which they are identical in regard to path-length for a given energy).

Gamma radiation, which is given off by a host of isotopes, is electromagnetic radiation and is not made up of discrete particles, as are the previously named radiations. As gamma radiation is absorbed exponentially, there is no absorber thickness which reduces the intensity to zero. Therefore, shielding against gamma radiation is difficult.

Protons (hydrogen nuclei), which have a path-length of several meters in air, can be stopped readily; they resemble alpha particles closely in this respect.

Neutrons have the mass of a helium nucleus, but no charge. As they have no charge, they can not be detected directly in an ion chamber. However, they are effective atomic "projectiles." When they enter a nucleus they often convert it to a radioactive isotope whose emission is detectable (for example, when they enter the nucleus of the boron-10 isotope, the nucleus disrupts, emitting an alpha particle and a lithium particle which are ionized particles that can be detected). Therefore, neutrons are detected by secondary means. *Fast neutrons* also may be indirectly detected by observing the ionization resulting from the proton emitted by a neutron-irradiated hydrogenous material, such as a plastic or an anthracene crystal. Neutrons in general are absorbed easily by thin layers of certain elements, such as boron and cadmium, each of which has a large cross-section capture area for neutrons (when

* *Chairman, Committee on Standardization of Nucleonic Laboratory Instruments, RTMA, and President, Radiation Counter Laboratories, Inc.*



Typical survey meters, which use ionization chambers and D'Arsonval meters to give beta or gamma radiation in mr/hr. Left, Beckman Model MX-5 beta-gamma survey meter: center, Victoreen Model 247-A survey meter: right, Radioactive Products Model D-1A "Cutie-Pie" survey meter.

the neutrons are of low energies). Neutrons are extremely penetrating when their energy is large; they are effectively stopped by slowing them down, or reducing their energy, with a "moderator" such as paraffin or water.

Sensing Elements

Eight different instruments are used for measurement of nuclear radiations—photographic film, conduction detectors, chemical integrating indicators, cloud chambers, ion chambers, proportional counters, Geiger-Mueller counters, and scintillation counters. Each of these instruments is a sensing element for ionizing radiation; associated circuits may be required to record the *intensity* of the radiation detected by the sensing element.

Photographic Film

Photographic film is the instrument with which Becquerel first discovered radioactivity in 1896. It still is one of the most widely used sensing elements for radiation, particularly in X-ray technique. The blackening of the photographic film is related to the quantity and quality of the radiation.

Personnel monitoring film badges are used widely in radioisotope laboratories. Each film generally contains a sensitive and insensitive film for low- and high-range beta- and gamma-ray monitoring. A particle emulsion film is used for monitoring fast and thermal neutrons. Fig. 3-1 shows a film meter of the badge and ring type, and also film packets typical of those commonly used for personnel monitoring.

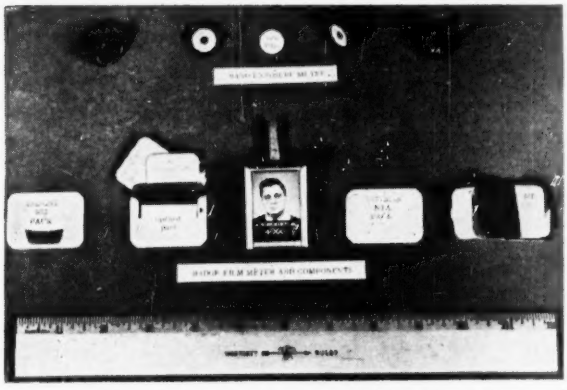


Fig. 3-1. Photographic-film meters of the badge and ring type, and film packets. (Photo courtesy Oak Ridge National Laboratory.)

While the opacity of the film resulting from radiation is used in personnel monitoring, recent developments—particularly with thick films in conjunction with detailed microscopic studies of the track resulting from incoming radiation—have furnished an important new tool for physicists. A wealth of information not previously known is available from close study of the straightness or irregularity of the track, from the number of developed grains per unit length, and from "stars" or many-pronged traces (particularly from the relative angles of these traces). Films are available which are more sensitive to one type of radiation than to another. Such films are used in cosmic-ray studies and in studies made in the vicinity of nuclear accelerators.

Two additional advantages of photographic films are their nearly permanent record of nuclear events and their resolution of the radioactive surface. However, films are not as convenient for recording individual nuclear events at high repetition rates as are ion chambers, counters, or photomultiplier tubes.

Conduction Detectors

Certain crystals, liquids, and solids have been used to detect radiation. A crystal with a particular lattice arrangement can serve as a dielectric across which is placed a suitable voltage. Radiation, piercing this dielectric, frees electrons which, because of the electric field, migrate toward the positive plate. This movement of charge is detected as a voltage pulse.

The advantages of such a system are (1) the high density of the dielectric yields increased sensitivity to gamma radiation, and (2) the pulse duration is exceedingly short. The disadvantages are (1) the difficulty of choosing suitable crystals, and (2) as the crystal counter continues to absorb radiation it polarizes and thus gradually reduces the magnitude of the voltage pulse. This detector offers promise, although it is still in the experimental stage.

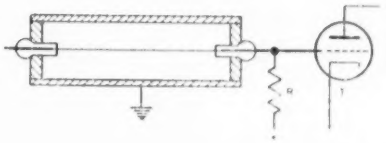
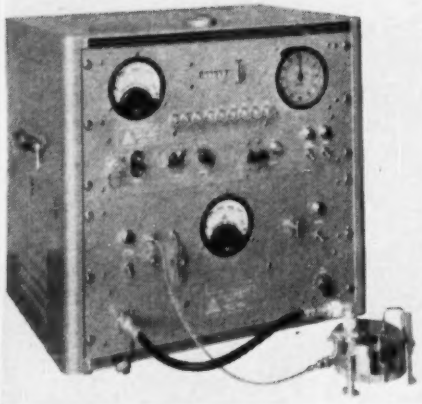


Fig. 3-2. Ion chamber connected to electrometer tube. When the detector is a proportional counter or Geiger-Mueller counter, a capacitor is used between the chamber and the grid of the tube.

Combination roentgen ratemeter and integrating meter, for use with ion chambers. D'Arsonval-type indicator shows rate of radioactivity in r/min.; integrator shows total dose in roentgens. (Photo courtesy Victoreen Instrument Co.)



Proportional counter unit connected to scaler-type nucleometer. (Photo courtesy Radiation Counter Laboratories, Inc.)

Portable alpha proportional counter for monitoring table tops, hands, etc. (Photo courtesy Nuclear Instrument & Chemical Corp.)

Chemical Integrating Indicators

Chemical indicators are solids or liquids which change color when subjected to radiation. The amount of color change is a measure of the quantity of radiation absorbed. Alkali halides such as LiF, KBr, and NaCl have been used for chemical integrating indicators for both high-energy photons and nuclear particles. Radiation dosage measurements have been based on the number of color centers formed in single crystals under X-ray and cathode-ray irradiation. The advantages of crystals are wide range of irradiation, high absorption, and small size. However, although currently useful for extremely high levels of radiation flux, chemical indicators are not nearly used as widely as are the other detectors. They are neither sensitive enough nor sufficiently quantitative to be useful in most laboratory experiments. They are used in some military applications.

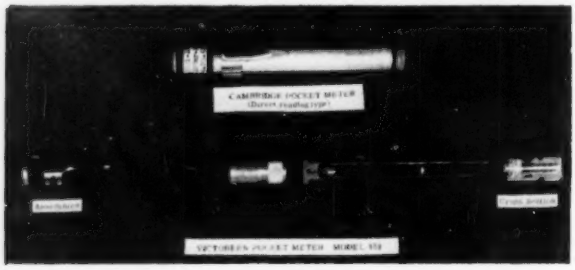


Fig. 3-3. Pocket-meter type of ion chamber, or pocket dosimeter. Upper meter is direct-reading type (made by Cambridge Instrument Co.); lower meter indirect-reading type (made by Victoreen Instrument Co.) which is charged and read by an auxiliary charger-reader unit.

Cloud Chambers

Probably one of the most powerful tools of the experimental nuclear physicist has been the Wilson cloud chamber, which has been used for studies of particles arising from cosmic radiation, high-energy accelerators, or nuclear reactors. This apparatus consists of a variable volume in which is placed a volatile liquid such as alcohol or water. Compression of the internal atmosphere followed by a sudden reduction of pressure above the liquid induces a supersaturation of the internal atmosphere. Radiation traversing this atmosphere leaves a path of ions, which serve as nuclei on which the vapor condenses to form visible droplets. Thus a visual record is made of the ionizing event. This record may be photographed and preserved. Among the advantages of the Wilson cloud chamber are (1) discrimination between radiations of different intensities, and (2) recording of rare nuclear events.

Ion Chambers

An ion chamber (Fig. 3-2) is a volume of gas in which a field is created by charged electrodes. Ions produced in the gas by an ionizing event are collected at the electrodes. The ion current is a measure of the character and intensity of the radiations. The gas amplification within the chamber is unity; hence the signal from the ion chamber requires considerable amplification before it can be recorded. The anode is generally from 1/10 to 1/100 the diameter of the cathode and is coaxial with it. A typical voltage across the electrodes is 100 volts.

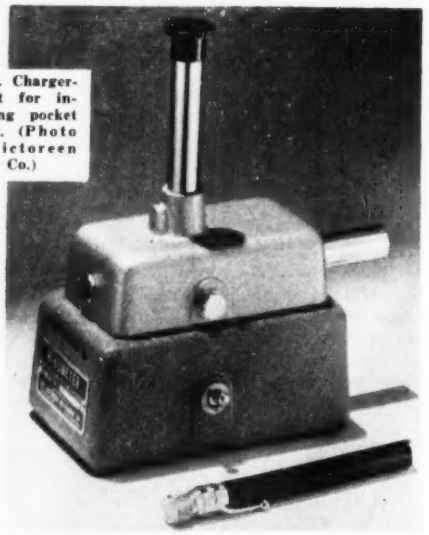


Fig. 3-4. Charger-reader unit for indirect-reading pocket dosimeter. (Photo courtesy Victoreen Instrument Co.)

Ion chambers are used widely as instruments in health work, inasmuch as they establish a linear relationship between the ionization formed by the radiation and the energy of the radiation. This aspect of ion chambers is important because the damage to body tissue by radiation is, to a first approximation, proportional to the number of ions formed in the tissue cell. This fact may be put in another way: the damage to body tissue is proportional to the amount of energy given up by the radiation per length of path.

A widely used type of ion chamber is of the personnel monitoring type. This instrument (Fig. 3-3), the size of a fountain pen, is called a pocket meter. It is essentially a cylindrical capacitor of high leakage resistance charged

Continued on page 1750

Theory and Filtering Technique for

COMPRESSED AIR

By PAUL M. HANKISON
Hankison Corporation

COMPRESSED AIR is a basic power-control medium; almost all modern industrial plants use it for important functions. Its advantages over other prime movers in control applications are many, but it has one serious drawback—every compressor, in addition to furnishing air, also produces contamination of one sort or another. Although devices for removing contamination from compressed air have been in existence for a long time, only recently have the filters and dehydrators been perfected to a degree that guarantees clean, dry, oil-free compressed air.

What is meant by "clean, dry, oil-free compressed air"? Air that is clean and dry enough for a jack hammer would be death to a delicately balanced pneumatic controller. By the same token, "instrument-quality" compressed air could not be used on many processes where the slightest amount of oil or water vapor would contaminate the end product. In each compressed-air application the amount of contamination that can be tolerated must be determined before deciding what type of equipment should be purchased for filtering and dehydrating.

Compressed-air Principles

Consider a cubic foot of air at atmospheric pressure and temperature, enclosed in a cylindrical vessel with a piston to apply pressure (Fig. 1). The air in the vessel, in addition to containing the normal gases of its own composition, also contains water vapor, oil vapor, and dust and dirt particles. In Fig. 1 the circles signify water and oil vapors; the solid dots signify dust and dirt particles.

Fig. 1,B shows what happens to the air after the piston is moved downward. If the air is compressed from 0 to 100 psig. its volume will be about 13 percent of that in Fig. 1,A.

If no heat is lost to the surroundings, the compression is said to be adiabatic*. During the adiabatic compression of Fig. 1, the energy applied to the piston manifests itself in the compressed air in the form of increased pressure and increased temperature. At 100 psig., the temperature will have increased from 60 to 485 deg. F., as shown in table 1. Let us now consider the water vapor in the air, particularly in terms of the relative humidity.

Relative Humidity

Relative humidity is defined as the ratio of the amount of water vapor contained in air at a given temperature and pressure to the maximum amount it can contain at the same temperature and pressure.

The greater the temperature of gas, the greater is its ability to hold moisture. For each rise of about 20 degrees in temperature, the capacity for moisture is almost doubled. For example, air at 60 deg. F. can contain a maximum of 5.75 grains of water per cubic foot. At 70 deg. F., the capacity is almost 8 grains. Hence, if air has 2.3 grains of vapor per cubic foot, the relative humidity is 29 percent at 70 F.; is is 40 percent at 60 F.; it is about 58 percent at 50 F.; it becomes 100 percent at about 35 F.

*Adiabatic compression is one in which all generated heat is retained.

Presented at Wayne County Section, Instrument Society of America, Wyandotte, Michigan, February, 1953.

As the temperature decreases, the relative humidity of the air increases proportionately. As the relative humidity approaches 100 percent we begin to see fog, which is visible evidence of the moisture. Saturation and 100-percent relative humidity mean the same thing; however, the total number grains of water necessary for saturation depends on the temperature.

Dew Point

Dew point is defined as the temperature below which water vapor is precipitated as liquid. For example, air with a relative humidity of 50 percent at 75 deg. F. becomes saturated if cooled to 50 deg. F.—thus, 50 deg. F. is its dew point. If we increase the temperature, the dew point remains at 50 deg. F; however, if we decrease the temperature below 50 deg. F., we exceed saturation, moisture condenses out of the air, and the dew point follows the temperature to its lowest value. If we again increase the temperature, the dew point remains at the lowest temperature reached by the air. Dew point corresponds to the wet-bulb temperature and is independent of normal dry-bulb temperature readings.

Contaminant Removal

Water is probably the most serious contaminant in compressed-air systems. Changes in temperature in the various parts of the system account for the water precipitated out at various points.

As shown in Fig. 1, at the increased temperature, the relative humidity of the compressed air in Fig. 1,B is less than that in Fig. 1,A. The amount of water has not changed, but the *capacity* to hold water has been increased. On the

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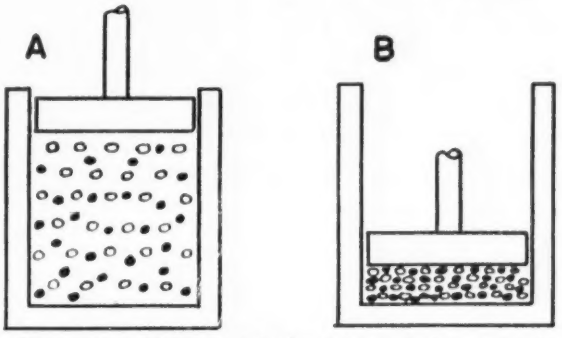

Fig. 1. Air containing contamination, before and after compression. Circles represent water and oil vapors; solid dots represent dust and dirt particles.

TABLE 1.—Temperature and Pressure Effects for Adiabatic and Isothermal Compression.

	Pressure (psig.)	*Temperature (deg.F.)*	*Relative Humidity*
A (original condition)	0	60	50%
B (after adiabatic compression)	100	485	38%
B (after isothermal compression)	100	60	100%

A DIFFERENTIAL-PRESSURE

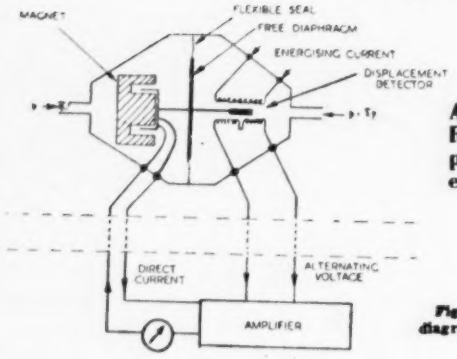

Fig. 1. Schematic diagram of instrument.

A differential-pressure meter developed by the British Iron & Steel Research Association for measurement of open-hearth furnace pressure can be installed close to the measuring point on the roof, eliminating errors due to buoyancy effects in connecting pipes.

PRECISE MEASUREMENT and control of open-hearth-furnace operating variables[1] can improve furnace efficiency. One of these variables is the pressure differential between the combustion chamber and surrounding atmosphere. A positive pressure in the furnace leads to flame "sting" at doors, with resulting heat loss and damage to doors and refractories; a negative pressure results in unheated air being drawn into the furnace, causing loss of combustion efficiency. Leckie[2] has shown that optimum furnace pressure conditions exist when the pressure differential at about sill level is zero. It is most convenient to measure the differential at the roof crown, at which point the pressure is about + 0.1-inch water because of "stack" or buoyancy effect in the furnace.

It has been stated[3] that errors of as much as 0.06-inch water can occur if the measuring instrument is remote from the furnace and connected to it by lengths of pressure piping, as when the instrument is mounted in a conventional control cubicle. Furthermore, these errors are subject to both cyclic and random changes of relatively large magnitude. It is desirable, therefore, that any pressure meter for use on open-hearth furnaces should have a detecting unit or head suitable for mounting on or near the furnace roof, and a remote amplifier and indicator.

Principle

The instrument developed by the B.I.S.R.A. to solve the problem consists of two units—a pressure head and an amplifier—together with indicators and recorders (Fig. 1).

The pressure head has two airtight chambers which are connected across the source of differential pressure. The chambers are separated by a rigid diaphragm which is freely mounted on a horizontal axis. Movement of this diaphragm under application of the pressure differential generates an alternating voltage in a displacement detector. After amplification and rectification, the signal voltage is used to apply to the diaphragm a force which opposes the original movement. This force is produced in a permanent-magnet-and-coil system and is a linear function of the output current of the amplifier. Thus the diaphragm moves until equilibrium of forces is reached, at which point the output current of the amplifier is a measure of the applied pressure differential.

Construction Details

Fig. 2 is an exploded view of the head unit. The rigid diaphragm (a 5-inch-diameter disk of paxolin) is carried on a horizontal axial rod of aluminum, supported by two inverted 'V' legs. A flexible annular seal of gold-beaters skin between the diaphragm and the main annular casting separates the head into two pressure chambers. One end of this axial rod carries a soft-iron armature which moves inside the displacement detector; the other end carries a coil moving in the air gap of the permanent magnet. Both displacement detector and magnet are supported on "spiders" of the type used in loudspeakers. Aluminum castings are used throughout the head unit.

The displacement detector consists of a long outer energizing winding and two short inner windings symmetrically disposed about the center of the unit. When the soft-iron core is centered in the coil assembly, there is equal flux linkage between the two inner windings. As the windings are connected in phase opposition, there is no resulting output voltage. Movement of the core results in an increased voltage from one coil and a reduced voltage from the other, so there is now a resultant output voltage. With 50 volts at 50 cycles applied to the energizing coil, the output voltage is about 0.7 volt per mm. displacement of the core, and is linear for movements up to 2½ mm.

* Presented by Dr. H. T. Clark, Jones & Laughlin Steel Corp., at the 1953 Instrumentation for the Iron & Steel Industry, Pittsburgh, Pa.

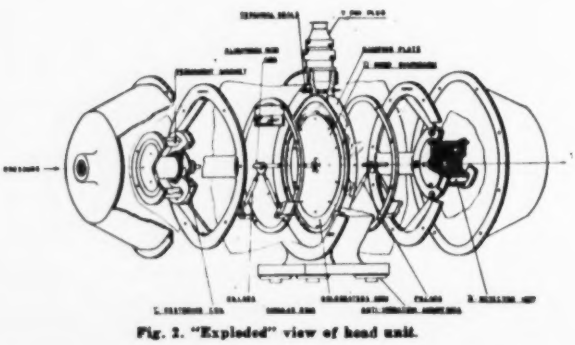

Fig. 2. "Exploded" view of head unit.

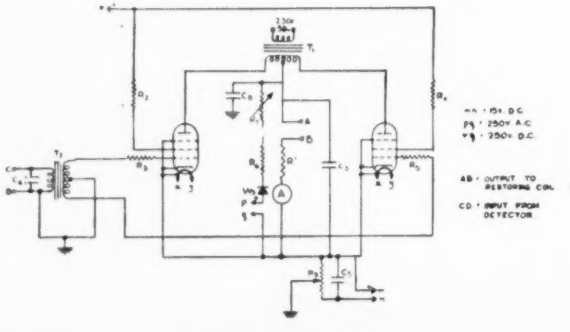

Fig. 3. Amplifier diagram.

METER FOR OPEN HEARTHS

By B. O. Smith
British Iron & Steel Research Association

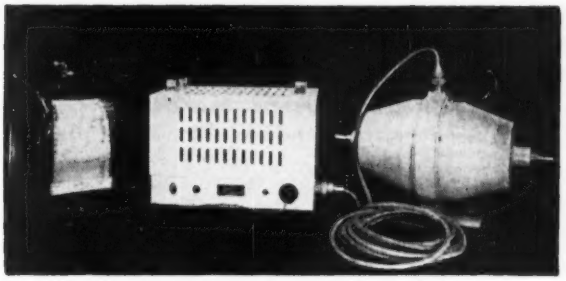

Fig. 5. Photograph of early laboratory model.

The restoring coil and magnet assembly is similar to that of a moving-coil loudspeaker unit. The flux density across the gap is about 2000 gauss and, with 600 turns in the coil, a force of 35 grams weight is generated by a current of 30 ma. (35 grams weight corresponds to a pressure differential of 0.1-inch water acting on a 5.2-inch-diameter diaphragm). The magnet dimensions are such that the coil can move ± 2 mm. from a central position and yet remain in a uniform magnetic field.

Fig. 3 is a circuit diagram of the amplifier. The voltage from the displacement detector is applied via transformer T_2 to the grids of two power pentodes (Type E.F.55), the anodes of which are fed out-of-phase by 400 volts at 50 cycles from the power transformer. Thus each tube conducts in turn for a half cycle. The signal to the grids is adjusted by C_4 to be exactly in phase or out-of-phase with the two anode voltages. The common cathode circuit carries a normal full-wave-rectified current. After filtering, this current is applied via terminals A and B to the restoring coil in the head unit. The reverse phase of input signal cuts off the tubes so that no output current flows.

To obtain precise control at low currents, it was found advisable not to operate the tubes near cut-off, and a standing current of about 2-3 ma. is provided by rectifier W_3 so that tube currents of approximately 2-32 ma. provide an output of 0-30 ma. This gives the further advantage that small negative pressures (up to −0.005-inch water) can be accommodated.

The amplifier has been designed to work into an output load of about 5000 ohms. Failure of one tube in the amplifier modifies the rectification action from full wave to half wave, but the instrument continues to operate at reduced efficiency.

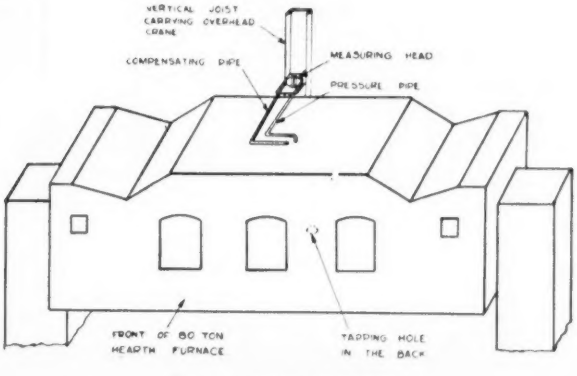

Fig. 4. A typical installation.

Performance

The principle of balancing applies nearly 100-percent feedback, so that high stability may be expected. In practice, at maximum applied differential, about 97 percent of the balancing force is generated in the magnet assembly, 2.5 percent arises from mechanical restraints in the moving system, and 0.5 percent reaction force from the displacement detector. It follows from this that, for example, a 50-percent change in the stiffness of the 'V' leg supports of the diaphragm would introduce only a 1.25-percent error in calibration. The real factor in long-term accuracy is the stability of the permanent magnet over a period of time. Experience has shown that no measurable errors in calibration occur over many months of operation.

The instrument has a speed of response of about ½ sec. It has been found expedient to use a recorder and indicator of longer time constant (say 5 sec.) so that integrated pressures are displayed, while retaining the high-speed response for application to a control system. Sufficient air damping is applied to the diaphragm in the head unit to give stability and freedom from oscillation.

A typical installation of the pressure head is shown in Fig. 4. The head was mounted at the level of the crown of an 80-ton furnace, at the back of the furnace and to the side of the tap hole. Short lengths of horizontal piping connected it to the roof crown, thus eliminating any buoyancy errors. A 6-way rubber-covered cable, 150-ft. long, connected the head unit to the amplifier.

A laboratory prototype of the instrument (Fig. 5) completed 18 months of reasonably trouble-free operation.

The instrument has been modified for use with an orifice plate as a flowmeter for gas or air. The only significant change in the design is replacement of the permanent magnet by an electromagnet energized in series with the restoring coil. Under these conditions the restoring force is now proportional to the *square* of the output current, provided that the flux density in the gap of the magnet is a linear function of the energizing current. As the applied differential pressure from the orifice plate is proportional to the square of the flow rate, the instrument becomes an air or gas flowmeter with a linear scale of flow rate.

Both versions of this instrument are now in commercial production.

References

(1) E. Rogers. *Journal of the Iron & Steel Institute*, Vol. 160, 1948, p. 57.

(2) A. H. Leckie; *Journal of the Institute of Fuel*, Vol. 16, 1943, p. 127.

(3) I. M. Halliday; *Journal of the Iron & Steel Institute*, Vol. 163, 1949, p. 145.

(4) S. S. Carlisle and B. O. Smith; *Journal of the Iron & Steel Institute*, Vol. 161, 1949, p. 222.

ELECTROMETER TUBES

Electrometer tubes are necessary for high-impedance pickups, such as ion chambers. Electrometer-tube characteristics, limitations, types, and basic circuits are presented.

By D. L. COLLINS
The Victoreen Instrument Co.

ELECTROMETER TUBES are vacuum tubes designed for measurement of electrostatic potentials or extremely small currents (less than 10^{-13} amp.)

Electrometer tubes are specially designed to have low grid current, and hence high input impedance. The grid current of the electrometer tube is kept low by using (1) a very good vacuum in the envelope, (2) low electrode potentials to minimize gas ionization, (3) low cathode emission current, and (4) proper grid potentials to assure that the cathode emission all goes to the plate. The tube may be operated in darkness to minimize photoemission from the grid, and the glass envelope is treated to keep its resistance high. With all precautions, grid currents as low as 10^{-17} ampere can be achieved.

Criteria for Electrometer Tubes

(1) Grid currents must be small in comparison to the unknown current being measured (when the tube is used in an integrating-type circuit).

(2) Changes in grid current, under all operating conditions, must be small (when the tube is used in a rate-meter).

(3) Stable and reproduceable plate currents at low electrode voltages are required.

(4) Changes in transconductance (G_m) must be minimized.

(5) High transconductance is desired for single-tube circuits.

(6) High amplification factor is desired for multiple-tube circuits.

Limitations on Electrometer Tubes

(1) *Shot effect* (E_s) is the statistical variation in electron flow to the grid. $E_s = (ei_gR/2C)^{1/2}$, where e is the charge of the electron, i_g is the grid current, R is the resistance of the grid, and C is the capacitance of the grid and associated circuit. For the Type-5800 tube, E_s is approximately (3) (10^{-5}) volt rms.

(2) *Johnson effect* (E_j) is thermal noise. $E_j = (kT/C)^{1/2}$, where k is Boltzman's constant (1.37) (10^{-23}) Joule per degree Kelvin, T is the absolute temperature in degrees Kelvin, and C is the capacity of grid and associated circuit in farads. Assuming 10^{-11} farad, E_j is approximately (2) (10^{-5}) volt rms.

(3) *Changes in the emission properties of the cathode surface* (E_n). These are minimized by aging the tube under its intended operating conditions. E_n for a carefully aged tube may be as low as 10^{-5} volt, equivalent grid voltage.

(4) *Photoelectric sensitivity of the tube elements.* For a properly designed electrometer tube, this is small in comparison to other sources of noise.

The total fluctuations (E) due to the above equals the rms. of the standard deviation in each individual fluctuation. $E = [(ei_gr/2C) + (kT/C)]^{1/2} + E_n^2$.

Ordinary Vacuum Tubes as Electrometers

Tube Types 1LN5, 32, 954, 959, and others have been used as laboratory electrometer tubes with limited success. For best results these tubes are operated with reduced filament voltage, a small positive voltage on the control grid G_1, negative bias and signal voltage on screen grid G_2, a low positive voltage on suppressor grid G_3 and on the plate. The latter two electrodes frequently are connected in parallel, serving as the anode.

As the tube manufacturer has no quality control on grid currents or any other characteristic at low-voltage operation, there is wide variation in performance. This necessitates selection, which is both time consuming and expensive in terms of rejects.

Tubes of the radio or hearing-aid variety have surface leakages which limit their performance as electrometers. They also exhibit greater drift in emission characteristics, which is of no importance in their intended application but is a severe limitation for electrometer purposes.

Electrometer Tetrodes

Electrometer tetrodes such as the Types 5800/VX-41A

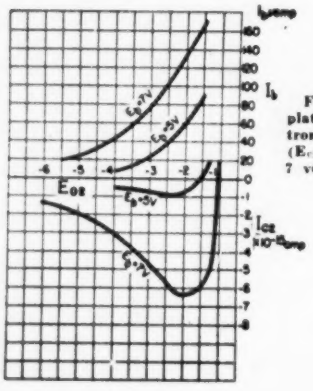

Fig. 1. Grid current (I_{c2}) and plate current (I_b) of Type-5800 electrometer tetrode vs. grid voltage (E_{c2}) for two plate voltages (5 and 7 volts).

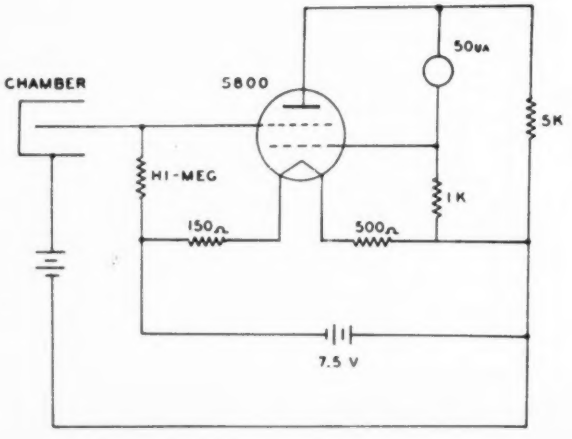

Fig. 2. Modified Du Bridge Brown circuit.

Paper presented on AIEE program at ISA Conference, Cleveland, Ohio. Sept., 1952, and contributed by the AIEE Sub-committee on ISA co-operation.

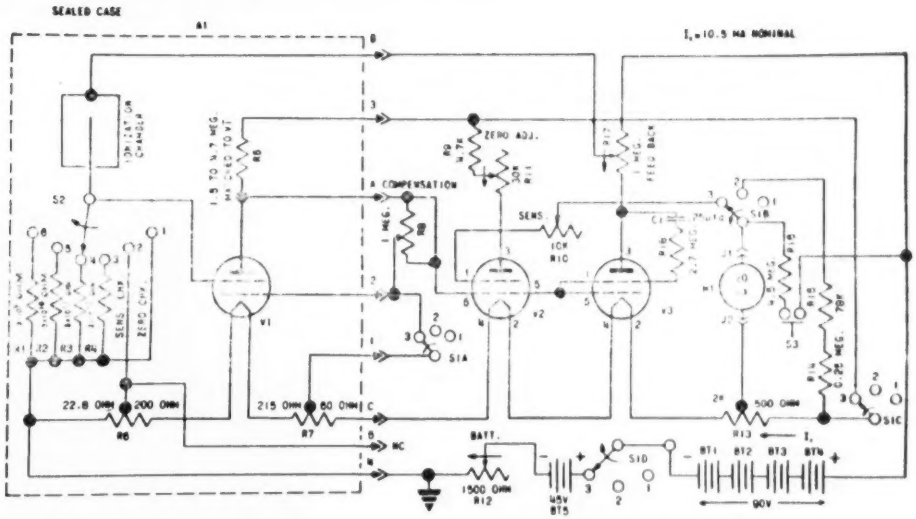

Fig. 3. "Model 247A" electrometer amplifier, used with ionization chamber and with positive feedback for rapid response.

and FP54, sometimes called *space-charge electrometers*, represent the ultimate in low grid-currents. The grid closest to the filament is operated at a low positive voltage, forming a virtual cathode. This grid repels the few positive ions which are emitted from the heated cathode, preventing them from being collected by the control grid. A high vacuum reduces the number of ions available, and the operating voltage ratings are set below the ionization potential of any gas which may be present. Special precautions are taken to reduce insulation leakages. Filaments are stabilized and operated at low temperature to reduce photoelectric emission from the grid.

These tubes have a voltage gain of unity and a transconductance of approximately 15 micromhos under optimum conditions. The current amplification is extremely high; their primary function is to reduce the impedance from the signal source.

Fig. 1 shows a typical grid-current curve of a Type-5800 tube operated under rated conditions. Operation is normally limited between cut-off and the region of zero IC_g. Note the large increase in grid current when the plate voltage is increased from five to seven volts. Much smaller grid currents are possible under controlled laboratory conditions.

Fig. 2 shows a typical one-tube circuit, a modification of the du Bridge Brown circuit, using the tube under rated conditions. The resistance network is selected so that the effect of battery aging on the filament, accelerator grid, and plate circuit is compensated for by changes of the control grid circuits, thus permitting the battery to be used over its entire rated life. This offers a comparatively simple design for field survey instruments. In a laboratory where maximum performance is required with higher input impedance, additional precautions should be taken: The voltages should be stabilized and the tube should be shielded against light and against magnetic fields; finally, the tube should be aged for approximately 100 hours.

The application of the positive electrode voltages should be delayed until the filament has warmed up (approx. 1/5 second in the 5800). This prevents destabilization of the oxide filament, which occurs when the tube operates emission-limited. The need for this precaution is masked by unstable emission in many tube types.

In Fig. 3, a two-tube victoreen circuit uses the same principle of compensation. It provides a variable compensation adjustment to allow for individual variation in vacuum tubes. Setting of this adjustment is required only when vacuum tubes are replaced. The third tube in the circuit is similar to that developed by Havens and Rainwater at Columbia for reducing the effective *RC* time-constant of the input circuit. It provides positive feedback through the chamber capacitance, which enables the circuit to anticipate the final signal level.

Owing to the positive feedback, this circuit oscillates if the gain is set too high. The gain may be set for a damped oscillation of a few cycles, in which case the response time

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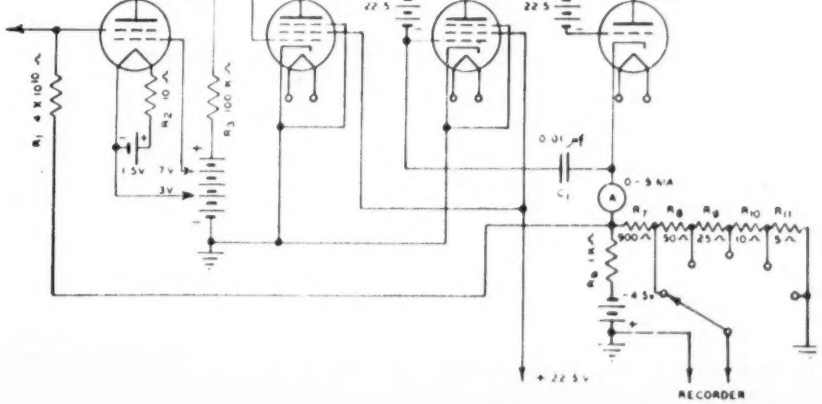

Fig. 4. Amplifier unit for mass spectrometer, which uses negative feedback for stability.

Use of alternating stress presents several important advantages in viscosity measurements for both Newtonian and non-Newtonian liquids.

RHEOLOGY OF FLUIDS

by WILFRED ROTH
Rich-Roth Laboratories

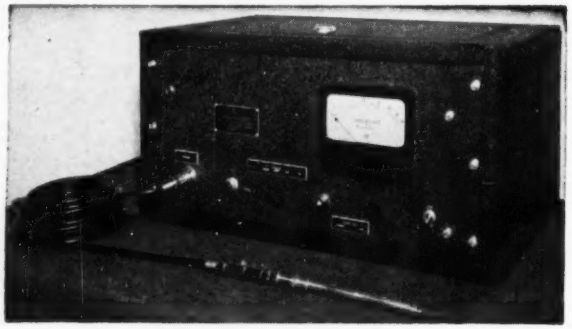

Fig. 1. The "Ultra-Viscoson"

RHEOLOGY is the science that deals with deformation and flow of matter. The elastic coefficient (or rigidity) of a material is the proportionality *parameter* that relates stress to strain. The word "parameter" is used rather than the word "constant" because only in special cases is the proportionality factor a constant.

In Newtonian fluids viscosity is a constant at any particular temperature, and the rigidity coefficient is zero. In non-Newtonian fluids the viscosity need not be a constant (and normally is not) and the rigidity coefficient is not zero, as is shown by a simple experiment: If a steady-flow system is set up, and if the pressure drop across a unit length of pipe is plotted vs. the velocity of flow, the shape of the curve depends on the physical characteristics of the material flowing in the system (Fig. 2).

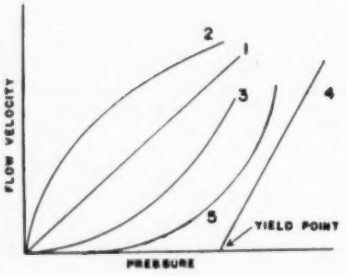

Fig. 2. Curves of flow rate vs. pressure drop for (1) Newtonian liquids, (2) dilatant materials, (3) thixotropic materials, (4) true plastics, and (5) pseudo-plastics.

Curve 1 in Fig. 2, a straight line, represents an ideal Newtonian liquid. (Materials such as simple lube oils, glycerine, and castor oil are Newtonian liquids.) Curve 2 represents a *dilatant* material—one in which the flow velocity approaches an upper limit as the pressure drop through the section increases. The opposite of a dilatant is called a *thixotrope* (curve 3); the velocity of flow increases faster than the increase in pressure. Curve 4 illustrates the characteristics of a *true plastic;* this material shows no flow at all until a certain minimum pressure (the yield point) is exceeded. Beyond the yield point the material behaves like any Newtonian fluid. Curve 5, which is more typical of actual materials, represents a psuedo-plastic because it is intermediate between a Newtonian and a true plastic. Newtonian liquids exhibit no elasticity or rigidity and, hence, no storage of potential elastic energy. In general, non-Newtonian liquids have shear rigidity.

Use of Alternating Stress

Recently, the measurement of elastic properties of materials under alternating stress (rather than direct or unidirectional stress, as heretofore had been exclusively employed) has become possible. This new approach in the rheological field is somewhat analogous to the relationship that alternating-current theory bore to the direct-current theory in the early days of electricity. The concept of viscosity normally employed in industry relates to measurement of resistance to flow when a material is subjected to a constant shear stress in a uniform direction, independent of time. The use of alternating flow permits measurement of the resistance to flow of a material subjected to cyclically alternating stress. It widens the field enormously because several other parameters now are available, each being characteristic of the material under measurement. These include the frequency of alternation of the stress, as well as the amplitude of stress.

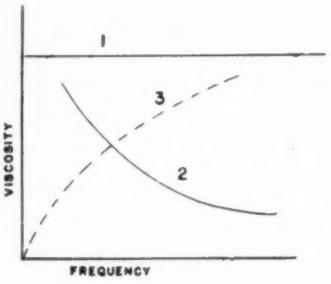

Fig. 3. Curves of viscosity vs. frequency of pump for (1) Newtonian liquid and (2) polymer. Curve (3) is the shear rigidity of polymer vs. frequency.

This extension to the classical viscosity theory can be illustrated by another experiment. If we take a continuous flow system and replace the unidirectional pump with a pump capable of alternating the direction of flow, we then can measure the resistance to flow and plot curves showing this resistance (viscosity) as a function of the *frequency* of alternation of the driving source (Fig. 3).

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*Presented before ISA Winter Conference meeting, New York, Feb 18, 1953.

DIGITAL COMPUTERS

Evolution of the complete process-controlling computer is advancing via improvements in storage devices and solid-state devices, and via greater understanding of the process and the computer.

By JAN A. RAJCHMAN
RCA Laboratories Division

IMAGINATIVE MINDS see in digital-computing machines the future tool for the automatic control of industrial, particularly chemical, processes.

Modern computers originated from fire-control and radar requirements of World War II. Early control computers were of the analog type—that is, the variables were simulated by continuously variable voltages or currents. The accuracy with which the variables could be combined to produce desired functional relationships in outputs was limited by the limits to physical measurement of the variables. Therefore, efforts were directed towards digital-type computers in which the variables of computation are deprived of direct physical reality and are considered as pure numbers in their digital form—and in which any desired degree of accuracy can be obtained simply by using enough digits.

Codes and "Switches"

The numbers are almost always coded in terms of bivalued, or "on-off," signals (Fig. 1.). For a given number (n) of signals there are 2^n combinations, so that a particularly convenient code is the binary numeration code, in which numbers are represented by a sum of powers of two. The usual decimal code also may be used by coding the ten digits by their corresponding binary number representation. The code is chosen by balancing the convenience of use against simplicity of computer construction.

Any arithmetical computation on two numbers to produce a third amounts to the performance of a logical transformation of the two bivalued signals, coding the result to the set of signals formed by the two inputs. This is a switching problem which, however complex it may be, can be accomplished by simple physical elements that need only to distinguish coincidences and anticoincidences of signals.

Presented at the 1953 Instrumentation for the Iron & Steel Industry, Pittsburgh, Pa.

BINARY NUMERATION SYSTEM		A CODED DECIMAL SYSTEM	
0	0	0	0000
1	1	1	0001
2	10	2	0010
3	11	3	0011
4	100	4	0100
5	101	5	0101
6	110	6	0110
7	111	7	0111
8	1000	8	1000
9	1001	9	1001
10	1010	957	1001 0101 0111
16	10000		
27	11011		

MORSE CODE — PUNCH CARD CODE

Fig. 1. Examples of codes with bivalued signals.

In early computers, radio-type receiving tubes were used as the fundamental "switching" elements. As a radio tube can be used reliably to combine only a few bivalued signals, many tubes are necessary to perform arithmetical operations involving many digits. In a pioneer spirit a large-scale machine, the ENIAC, having more than 20,000 tubes, was built at the University of Pennsylvania.

Universal Computer

After the war it was realized that the great speed and accuracy of electronic digital computation could be used to solve by numerical methods a great variety of scientific and technical problems defying straight analytical methods. It was realized also that a universal digital computer could be made by making two additions to the arithmetical computer: a *storage device* and a *control device* responding to a coded program (Fig. 2).

The storage or memory device makes it possible to retain intermediary results and allow a chain of computations in which the result of one becomes the basis for the next. The extremely long chains of calculations must be programmed carefully in advance because many human interventions during the course of the computation are obviously excluded. As a program is specific for each problem, it can not be built-in because the machine would be useful only for that problem. To render the machine universal, the program is coded—that is, expressed in terms of groups of bivalued signals similar to those which express the variables of computation.

Numbers and instructions, both coded similarly, are inserted from the input of the machine into its memory. The control recognizes the instructions and makes the machine execute them.

Instructions consist of the addresses within the memory of two numbers to be operated on, the specification of a desired arithmetical operation to be performed on them, and the addresses within the memory where the result of the operation is to be stored. Instructions usually are executed

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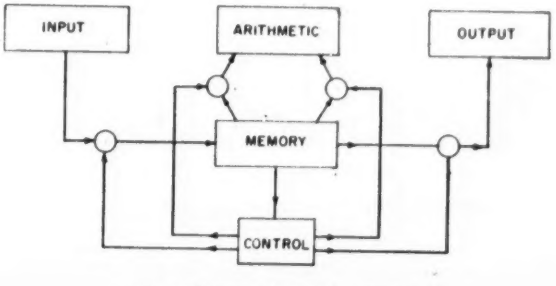
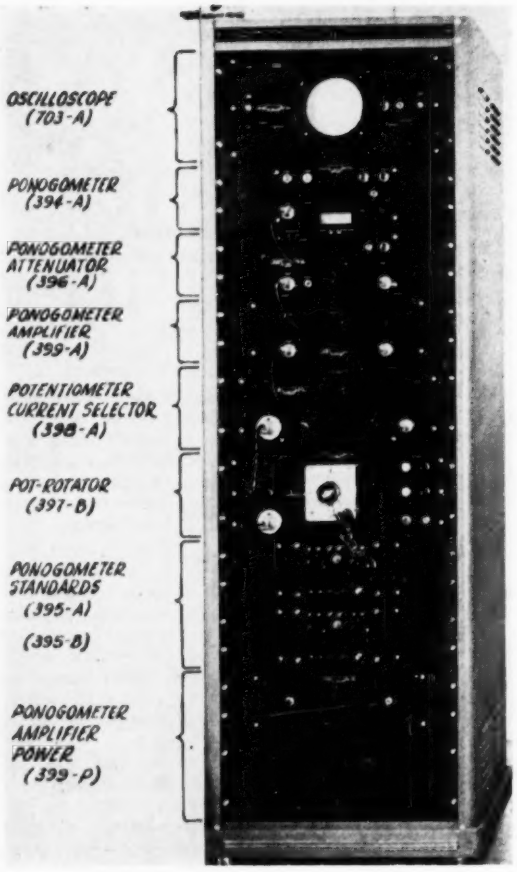


Fig. 2. Diagram of digital computer.

RESIDUAL POTENTIOMETER NOISE

by J. R. ALTIERI
Technology Instrument Corp.

Noise in the output of actuated wire-wound potentiometers is particularly prevalent in precision potentiometers because of the low brush tensions required to achieve long life and critical accuracy under conditions of continuous actuation.



Potentiometer Noise Analyzer

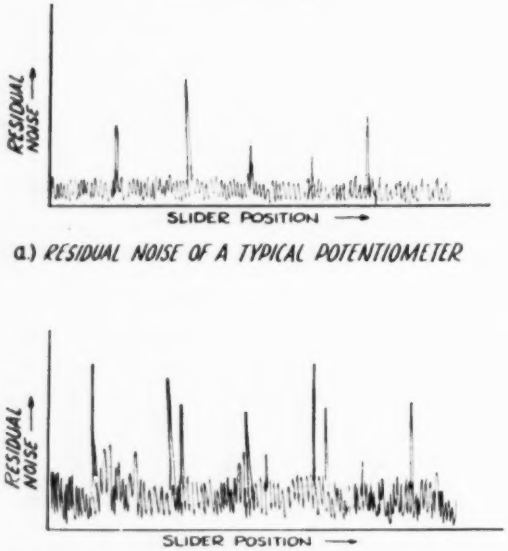


Fig. 1. The general character of residual noise as a function of slider position and time.

WIRE-WOUND PRECISION POTENTIOMETERS are playing an increasingly important role in electronic and electromechanical systems. Potentiometers produce a voltage output that depends on the angular position of the slider. However, the output may deviate from the desired value because of (1) nonlinearity (or nonconformity in nonlinear potentiometers), (2) resolution fluctuations, and (3) residual noise.

Nonlinearity or *nonconformity* can be attributed to errors in the resistance gradient of the wound resistance element of the potentiometer. These errors of a given potentiometer are systematically repeatible; however, for a production run of such potentiometers (i.e., for a *class* of potentiometers) these errors are apt to be random.

Resolution fluctuations are periodic step-wise voltage variations caused by the slider contact moving across the discrete turns of the resistance winding, and are thus a property of contact and winding design[1]. Associated directly with resolution fluctuation is a rapid voltage perturbation known as shorting noise[2].

Residual noise, the third cause of potentiometer inaccuracy, is the subject of this article. Elusive and hardly predefined, residual noise is developed in wire-wound potentiometers when they are mechanically actuated, both with and without electrical excitation. As shown in Fig. 1, residual noise varies sharply with slider position. It also varies with time, and even from one slider cycle to the next.

Residual potentiometer noise depends on the potentiometer structure and on the circuit application. Significant structural aspects are slider contact pressure, wire size and spacing, and composition and condition of the wire. Important application factors are total resistance, effective slider travel, over-all size, excitation current, load current, forward gain, circuit impedance level, stray pickup, operating temperature, etc. The potentiometer designer and user should understand the interplay of residual-noise causes.

ACTIVE AND PASSIVE RESIDUAL NOISE

When the slider of a wire-wound potentiometer is moved, residual noise appears at the contact interface between

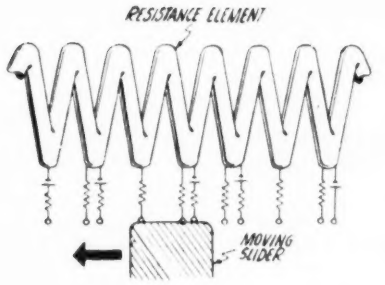


Fig. 2. Representation of active and passive noise sources between winding and slider of wire-wound potentiometers.

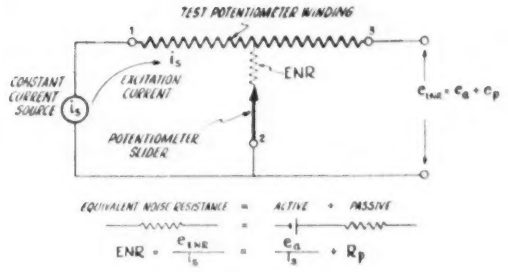

TEST POTENTIOMETER WINDING
CONSTANT CURRENT SOURCE
EXCITATION CURRENT
ENR
POTENTIOMETER SLIDER
EQUIVALENT NOISE RESISTANCE = ACTIVE + PASSIVE
ENR = e_ENR / i_s = e_a / i_s + R_p

Fig. 3. Circuit for measuring equivalent noise resistance, ENR.

the resistance winding and the moving slider. This noise is of two basic types, which have been defined as *active noise* and *passive noise*[3]. These terms are used because the noise can be accurately represented by active and passive electric circuit elements (Fig. 2).

Active residual noise, the smaller of the two components, appears at the potentiometer output even though the potentiometer is not excited. These voltages are generated when the slider is moved and can be represented by active circuit elements, such as small voltaic cells, in the interface between the winding and the slider (Fig. 2).

Passive residual noise is evident only when excitation current flows in the potentiometer winding. Its principal cause is the fluctuating contact resistance between the moving slider and the resistance element. This resistance is in series with the slider and the circuit. The slider may contact one or more turns of the resistance winding, and the contact resistance thus also appears in parallel with the shorted resistance turns. Care should be taken to delineate between the passive contact resistance changes due to slider motion and the resolution fluctuations associated with the shorting effect also caused by slider motion. As it is purely resistive in nature, passive residual noise can be represented by passive resistance elements between the slider and the potentiometer winding, as in Fig. 2.

Principal Causes of Residual Noise

A major source of passive residual noise is contamination of either the potentiometer winding or the slider contact by either dust particles, products of abrasion, or other foreign materials. Contact resistance fluctuations due to this cause usually are large, relatively stationary with respect to time and slider position, insensitive to slider speed, and occasionally dependent on contact current density. Contact resistance peaks due to dust and foreign insulation materials can range up to several megohms. Accumulations of slider and resistance-wire erosion by-products can cause contact resistances from one hundred to several thousand ohms.

An elusive type of contamination is oxide film on one of the contact surfaces. This cause is difficult to track down and is current-density sensitive, apparently undergoing sharp decreases in ohmic magnitude at a critical value of slider current. Oxide contamination is unstable and varies widely with time and environmental conditions.

Another source of passive residual noise is mechanical discontinuity between the slider and the resistance element. Contact resistance fluctuations of this sort are large in magnitude, stable with respect to time and slider position, and are insensitive to contact current density. They are, however, critically dependent on slider velocity, and can result in open circuits at sufficiently high speeds.

There is a fundamental physical limit to how small the contact resistance between two sliding surfaces can be made[4]. The so-called "constriction resistance" fluctuations are generally random in character, small in ohmic magnitude, and are considered responsible for the grassy-like pattern of random residual noise shown in Fig. 1. The level of constriction resistance is established by the hardness of the resistance wire and slider contacts, the specific resistivity of the wire and contact, the contact geometry, and the mass, pressure and elastance of the contact suspension system. Typical values of constriction resistance fluctuations for present-day wire-wound precision potentiometers are in the order of tens of ohms. Experimental models have been made with fluctuations as low as one ohm.

The causes of active residual noise are less easy to trace. Possible sources of self-generated voltages, in the presence of slider motion, are (1) the *tribo-electric effect*, which derives its electrical energy from the abrasive action of the slider rubbing on the resistance wire, (2) the *thermo-electric effect*, which depends on external or frictional heat for its existance, and (3) *chemico-electric effects*, which can be traced to different work functions at the point of contact or to chemical contamination of the resistance wire.

Whatever their cause, active electrical disturbances in wire-wound precision potentiometers rarely exceed a few hundred microvolts in magnitude. The character of active residual noise is far less random than pasive noise. Noise peaks are approximately one per turn of resistance wire and are nearly constant in magnitude. The polarity is constant and independent of the direction of slider rotation. Active noise varies with slider velocity, slider pressure, and the chemical composition of the slider and winding materials. Unlike passive noise, the peak magnitude and waveform of active noise voltages are predictable during potentiometer design.

Measurement of Equivalent Noise Resistance

It is desirable to make quantitative potentiometer-noise measurements. An effective noise measurement circuit is shown in Fig. 3. A source of constant current is placed across one arm of the potentiometer and the slider. The slider and the other arm of the potentiometer are joined to a voltage-measuring circuit having a high input-impedance. Owing to the high impedance of the voltage output circuit, the entire source current i_s flows through the left-hand portion of the potentiometer and through the slider.

If the source current is zero, the noise voltage measured at the circuit output can be attributed entirely to the active noise potential at the slider contact. When the source current is applied, a voltage drop appears across any passive resistance which may exist at the slider point of contact. This passive noise voltage adds directly to the active noise voltage.

The total voltage output of the circuit is the sum of active and passive residual noise components. Although the two types of noise are of quite different nature (one is a generated voltage and the other is a passive resistance) it is helpful to express both active and passive noise components as ohmic resistances. The total of these resistances is called the *equivalent noise resistance* and is defined as the total residual noise voltage divided by the source current (Fig. 3).

The equivalent passive noise resistance appears directly as resistance R_p. The equivalent active noise resistance, however, is the ratio of the active noise voltage (e_a) to

Continued on page 1734

Gun-barrel Measurements Involve

RAPIDLY FLUCTUATING TEMPERATURES

by J. M. CHENOWETH, J. E. BROCK, C. R. ST. CLAIR and G. A. HAWKINS
Purdue University

DEVELOPMENT of accurate gun barrels with long life at high rates of fire requires knowledge of the transient temperature distribution during firing. Temperatures must be measured at various radial and longitudinal positions in the barrel of an automatic weapon as functions of time. In particular, the temperatures at the inner bore surface and in close proximity to that surface are required. As the bore temperature reaches a high value in a time interval of approximately one millisecond, the temperature-measuring apparatus must (1) be rugged, (2) have small dimensions, and (3) have rapid response.

German researchers reported[1] in 1941 an experimental apparatus for measuring temperatures in the bore-surface region. The apparatus consisted of a bore-surface thermocouple unit, a direct-coupled amplifier, and a Siemens and Halske recording oscillograph. The thermocouple was composed of an oxidized nickel wire fixed concentrically within a steel plug. The thermocouple junction was formed by electroplating a layer of nickel on the composite end of the plug. By means of this apparatus a maximum temperature of 825 deg. C. was detected at the bore surface at a distance of 90 mm. from the breech end of a machine gun barrel within 1 millisecond after firing. Other German reports[2,3] present similar approaches to the problem. This article discusses the techniques and apparatus developed at Purdue University, including the expansion of the information by use of the thermal analyzer.

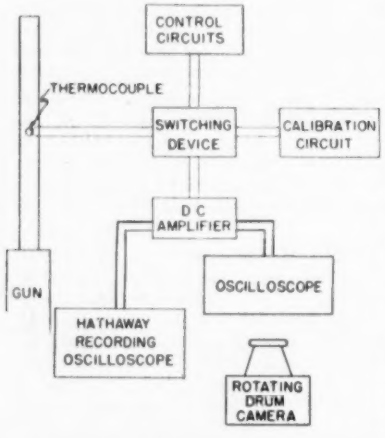


Fig. 1. Schematic of bore-surface and in-wall temperature-measurement systems. Camera is used for bore-surface measurements; recording oscilloscope for in-wall measurements. Different DC amplifiers are used for the two measurements.

Experimental Apparatus

The first phase was development of an apparatus consisting of (1) special thermocouples, (2) a rotating selector device for introducing the emf. of the thermocouples separately and in a cyclic manner into the recording system, (3) a resistance-capacitance-coupled amplifier, (4) a cathode-ray oscilloscope, and (5) a rotating drum camera for indicating and recording the data.

The *selector device* consisted of a motor-driven rotary switch of the two-pole, multiple-throw type. It connected both sides of a given thermocouple unit to the input of an amplifier, while simultaneously maintaining open circuits in both wires of each of the other thermocouple units. The resulting pulsating voltage was fed into a resistance-capacitance-coupled amplifier.

Although a double-pole switch was the ultimate objective, the sequence of design was first to develop a single-pole unit with phosphor-bronze brushes. This unit was capable of switching one side of one thermocouple at a rate of 1800 times per second or one side of six thermocouples at a rate of 300 times per second. It was used successfully to obtain a record of the temperature of a 37-mm. gun barrel during the firing of one round at a radial distance of 0.01 inch from the bore surface. However, the switch required constant maintenance.

A more satisfactory double-pole multiple throw switch was developed which used mercury streams instead of phosphor-bronze brushes. Two rotors each with a set of mercury nozzles were used; one rotor for the positive side of the circuit and one for the negative. This switch was operated successfully at 1800 rpm., which corresponded to switching both sides of a single thermocouple at a rate of 300 times per second. Owing to the problems associated with the handling of mercury and maintenance of various elements of the apparatus, it was decided to abandon the switch and to consider other approaches.

The second phase of the program consisted of a study and development of an apparatus composed of a thermocouple unit, a direct-coupled amplifier, and either a cathode-ray oscilloscope with rotating drum camera or a recording oscillograph, as shown in Fig. 1. By means of the apparatus, temperature measurements were made both in the region of the bore surface and within the wall of a gun barrel. Different structural and thermal requirements were necessary for the bore-surface and the in-wall temperature-measuring elements.

Temperature Apparatus

The basic *bore-temperature* measuring apparatus (Fig. 1) consisted of a thermocouple unit for detecting the temperature; a direct-coupled amplifier, a cathode-ray oscilloscope with a rotating-drum camera for indicating and recording the phenomena, plus auxiliary circuits for calibration and synchronization. The component labeled "switching device" was a relay-operated circuit for introducing either the "calibration" or "control unit" into the circuit in series with the thermocouple. The "calibration unit" consisted of a potentiometer circuit for placing known voltages on the oscilloscope record. Comparison of the actual firing record with the known voltages and the use of a previous thermocouple calibration enabled the interpretation of the firing

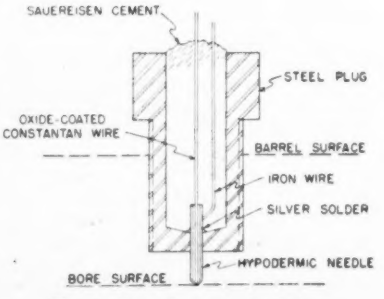


Fig. 2. Bore thermocouple design.

record in terms of temperature. The "control unit" included circuits for (1) placement of timing lines on the oscilloscope record, (2) introduction of a mark on the record that indicated the instant of time at which the projectile left the muzzle, and (3) delay of both the firing of the gun and the operation of the camera shutter in order to synchronize the various steps of the recording process.

For *bore-surface measurements* a thermocouple (Fig. 2) was developed that consisted of a single, oxidized-constantan wire contained within a stainless-steel hypodermic needle. The junction was formed by crimping the end of the needle and silver-soldering it to the wire at the tip. A polishing process completed the construction of the junction. The needle was fixed in a steel plug by silver-soldering, and the plug was threaded for entry into the barrel wall. An iron wire was attached to the steel needle and, as the thermoelectric potential of the iron-steel junction was negligible, the unit was essentially a steel (or iron) and constantan thermocouple. Refractory cement held components of the unit in place. The junction was 0.003-inch thick plus or minus 0.001 inch.

This construction produced a thermocouple with a hot junction at least partly formed by a layer of silver solder. Silver solder melts at a temperature below the temperatures expected at the bore surface; however, temperatures as high as 1900 deg. F. were recorded and structural failure did not result under firing tests of several rounds.

The basic measuring circuit for in-wall temperatures was the same as the one for bore-surface measurements except the former employed a Hathaway recording oscillograph in place of the cathode-ray oscilloscope. However, an additional circuit was introduced to place marks on the record that indicated the time intervals between the chambering of successive rounds. The voltage amplifier used with the latter was replaced by a voltage amplifier with a current output.

The specifications for an in-wall thermocouple unit were somewhat less demanding than those for the bore-surface temperature detector. As the extreme pressures of the explosion process did not act directly on the in-wall thermocouple, the unit could be less rugged in design than the bore-surface thermocouple. It was necessary, however, to have a junction accurately located so that contact resistances to heat flow were reduced to a minimum. Furthermore, the change in temperature distribution in the barrel wall by the insertion of a thermocouple had to be considered.

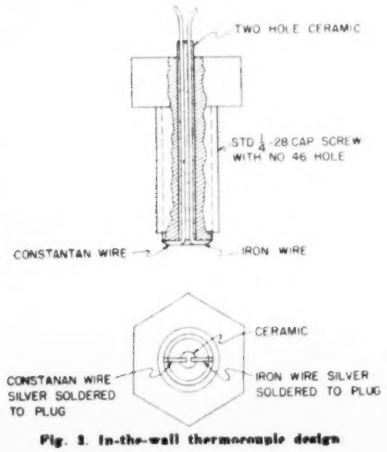

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Fig. 2. In-the-wall thermocouple design

An in-wall thermocouple unit (Fig. 3) was constructed of two dissimilar wires, iron and constantan, that were passed axially through a ceramic insulator, which in turn was placed in a steel plug. Each wire was bent at a right-angle to the axis of the plug at the junction end and silver-soldered to diametrically opposite spots of the steel wall. A polishing process reduced the thickness of the junction to 0.005 inch plus or minus 0.001 inch. Care was taken in the preparation of the hole in the barrel wall to avoid thermal resistances at the seat. The hole was drilled and bottomed to be flat, and the thermocouple unit was seated securely.

Results

A firing record of a bore-surface thermocouple for a three-round burst is shown in Fig. 4. The "muzzle break trace" indicates when the projectile left the barrel relative to other phenomena, and the "calibration pulse" shows the vertical displacement equivalent to a given known voltage. The "timing marks" interpret horizontal distance in terms of time. A graphical plot of bore-surface temperature versus time for the three-round burst showed that the peak temperature rise of the initial round was about 1700 deg. F., followed by cooling to 600 deg. F.; the second round produced a peak of about 1870 deg F. and cooled to 800 deg F.; the third round caused a rise of 1900 deg. F.

A firing record of a five-round burst with an in-wall thermocouple located 0.032 inch plus or minus 0.002 inch from the bore is shown in Fig. 5. The "muzzle break trace" indicates when the projectile left the barrel and the "bolt switch trace" indicates the time intervals between the chambering of successive rounds. Each chambering is indicated by a circle enclosing a number with an arrow pointing to the jump in the trace. The numbers refer to the rounds fired. The wavy nature of the temperature trace was caused by 60-cycle modulation. A graphical plot of in-wall temperature versus time for the five-round burst at a radial position of 0.032 inch is given in Fig. 6. A peak temperature rise of about 570 deg. F. was reached after 330 milliseconds from the start of firing.

Thermal Analyzer

An analogy between the thermal and electrical circuits is based upon the similarity of the basic equations describing thermal and electrical phenomena. The staff of the Department of Engineering, University of California, Los Angeles, demonstrated the use of a thermal analyzer for the study of the temperature distribution in gun barrels under various firing conditions in 1945. The experimental temperature data obtained at Purdue University has been used to establish the boundary conditions and to spot-check results obtained on the analyzer. The experimental radial temperature distribution for a given time has been accurately simulated on this unit. Studies of the influence of cyclic rate, geometrical shape of the barrels, etc. are in progress.

Continued on page 1738

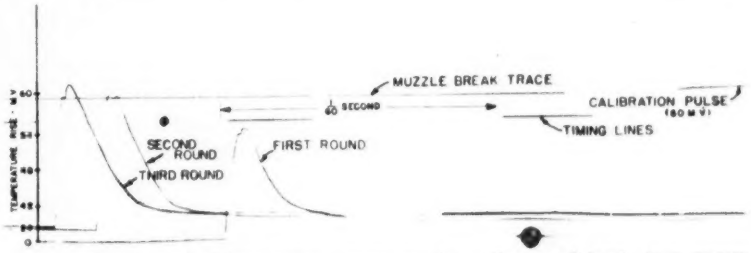

Fig. 4. Firing record of bore surface temperature for a three-round burst. drum camera recorder.

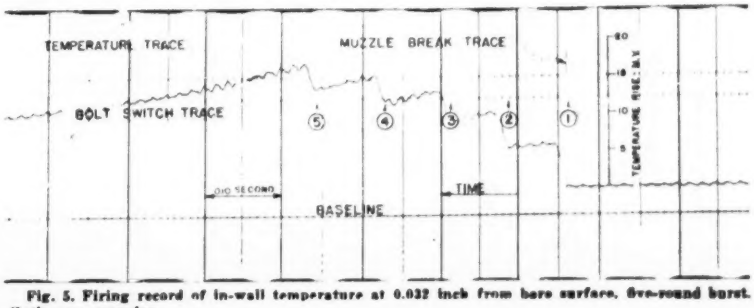

Fig. 5. Firing record of in-wall temperature at 0.032 inch from bore surface. five-round burst. Hathaway recorder.

Prediction of gas-flow performance of
ROTAMETERS

Engineers frequently are confronted with the problem of predicting performance of a rotameter used on a fluid for which calibration data are lacking. A technique is described for gaseous fluids—provided one set of calibration data is available and the float is viscosity immune.

by JOEL O. HOUGEN
Rensselear Polytechnic Institute

IT has been shown by Martin[4] that correlation of the form shown in equation 1 should result for rotameters under conditions where geometric similarity exists:

$$Q\rho/D\mu = f\,[(v_{ft}\rho)(\rho_{ft} - \rho)g/\mu^2] \qquad (1)$$

Thus for constant float and tube dimensions, a correlation would be expected at each position of a float of a given shape. Verification of this was presented by Martin for one tube using different float materials and a variety of liquids. In view of the constancy of both D and g, simplification is obtained for a given tube and float size:

$$Q\rho/\mu = W/\mu = f\,[\rho(\rho_{ft} - \rho)\ /\mu^2] \qquad (2)$$

Martin further showed that at sufficiently high values of $Q\rho/\mu$, (especially at high float elevations, where freedom from drag-coefficient variations exists) the functional relation should be of the form:

$$Q\rho/\mu = B'[\rho\ (\rho_{ft} - \rho)/\mu^2]^m \qquad (3)$$

where m approaches ½.

Rotameter manufacturers have spent much effort in designing floats which give freedom from drag-coefficient changes over as wide a flow range as possible. Where m equals ½:

$$Q = B'[(\rho_{ft} - \rho)/\rho]^{1/2} \qquad (4)$$

from which arises the familiar formula for predicting flows for one fluid from calibration data on another:

$$Q_1 = Q_2[(\rho_{ft} - \rho_1)(\rho_2)/(\rho_{ft} - \rho_2)(\rho_1)]^{1/2} \qquad (5)$$

Manufacturers commonly supply flow calibration data for only air and water at some standard conditions. Thus it is impossible to establish a reliable generalized correlation and especially to know at what point deviations from equation 3 occur.

Upon request some manufacturers will supply calibration data for several fluids; in such instances the generalized calibration can be developed and the reliability of flow equations such as equations 3 or 4 determined, as will be shown for a typical small-capacity precision rotameter for which calibration data were supplied for four different gases.

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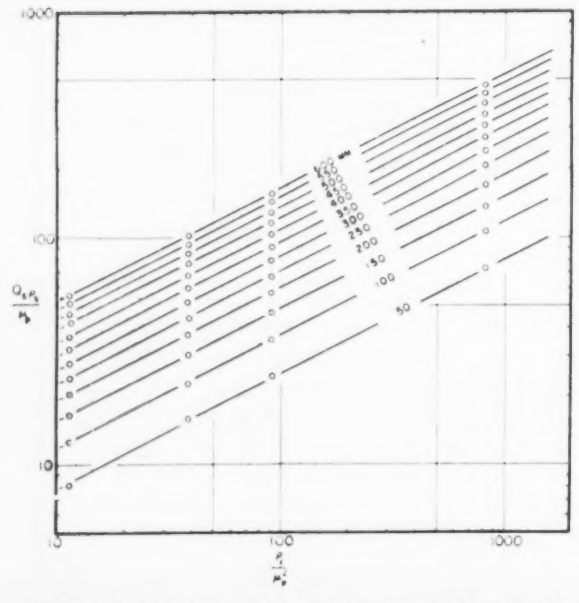

Fig. 1. Plot of $Q_{air}\rho_{air}/\mu_{air}$ vs. ρ_f/μ_f^2 for a 600-mm. tube flowrator using various gases.

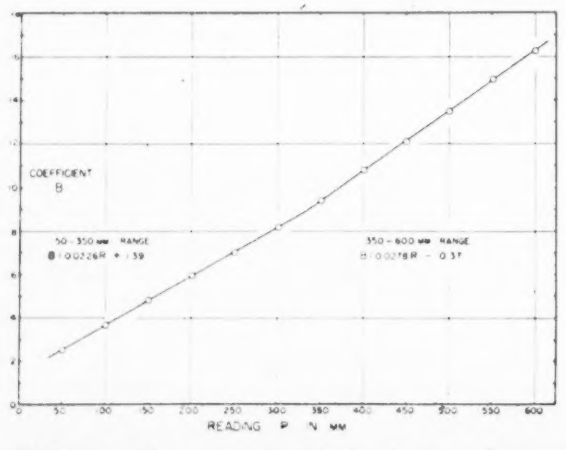

Fig. 2. Flow coefficient for 600-mm. tube flowrator for gas flow measurement.

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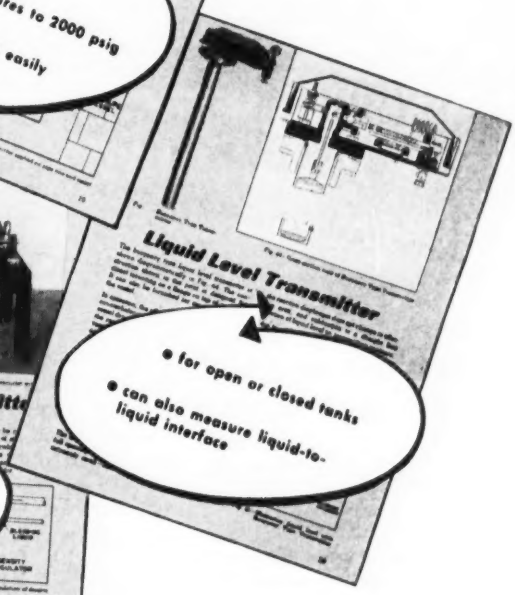

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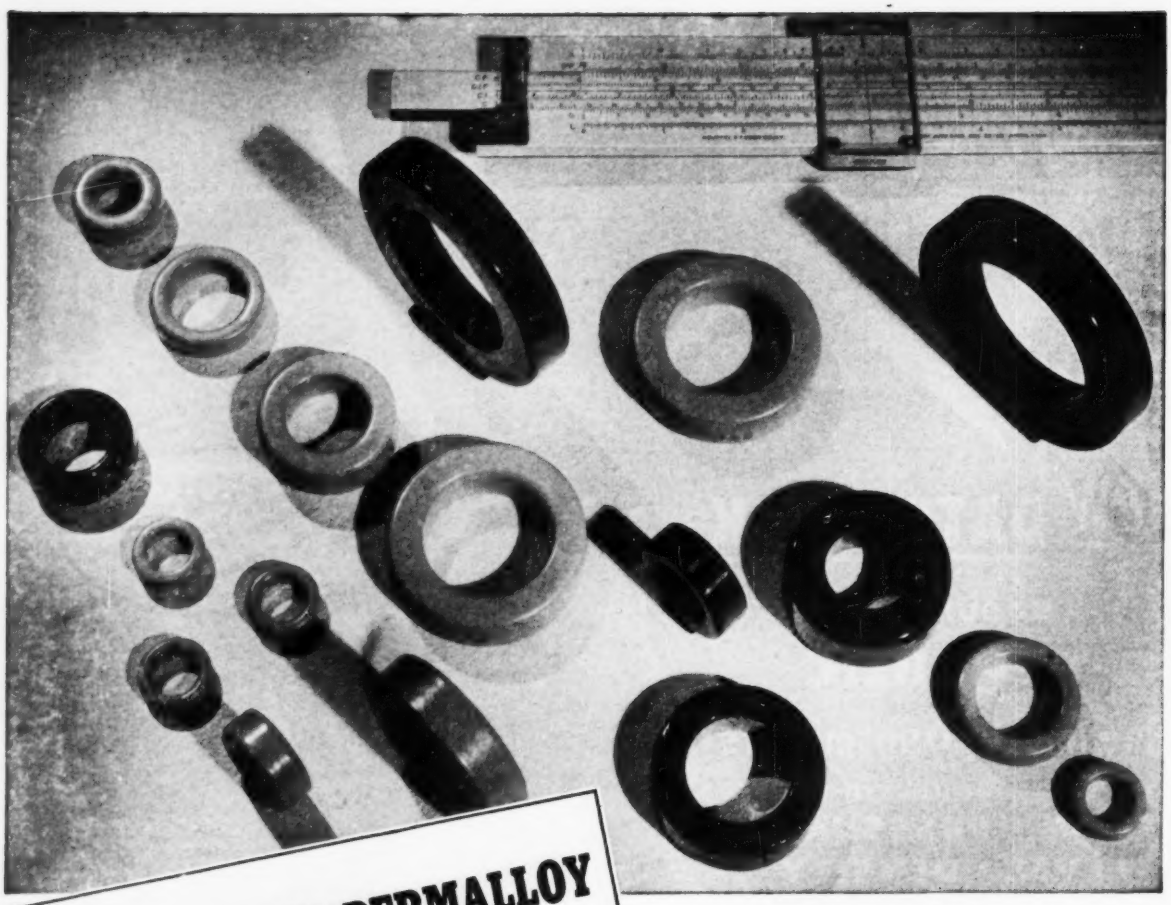

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D. A. Spitz, Froedfert Malting Co., 38th St. and W. Grant, Milwaukee 15, Wisconsin.

MONTREAL
W. L. Toohey, Dominion Textiles Ltd., 1950 Sherbrooke St., West, Montreal, Tel. GI 5711
Last Monday of month, Meeting 8:00 P. M.

MUSCLE SHOALS
Frank W. Potter, T.V.A., Wilson Dam, Ala.
First Thursday, Meeting 8:00 P.M., TVA Chemical Engineering Bldg.

NEW JERSEY
Eliot R. Hill, 1125 Kensington Ave., Plainfield, N. J.
First Tuesday, Meeting 8:00 P. M., Essex House Hotel, Newark, N. J.

NEW YORK
R. A. Hutcheon, 45-65 196th St., Flushing 58, N. Y., Tel: BAyside 9-5432
Third Monday, Dinner at 6:00 P. M., Meeting at 7:30 P. M., Midston House, 38th St. & Madison Ave.

NIAGARA FRONTIER
Duran L. Hagler, 214 E. Delavan Ave., Buffalo, N. Y., Tel: ELmwood 1258
Fourth Monday, Dinner at 6:00 P.M. Meeting at 8:00 P. M., N.Y.S. Technical Institute.

NORTH TEXAS
R. E. Byers, 6000 Lemmon Ave., Dallas 9.

NORTHEAST TENNESSEE
S. E. Abernathy, c/o Equipment Sales Corp., 341-345 W. Market St., Kingsport, Tenn.

NORTHERN CALIFORNIA
George W. Killian, 3718 Ramsey Court, El Sobrante, Calif. Tel: BEacon 4-0523
Third Monday, Meeting 8:00 P M.

NORTHERN INDIANA
J. B. Beckman, 7145 Wicker Ave., Hammond, Ind. Second Tuesday, Meeting at 8:00 P. M., Whiting Community Center, Whiting, Ind.

OAK RIDGE
Thomas M. Gayle, 117 W. Vanderbilt Drive, Oak Ridge, Tenn. Tel: 2-1516.
First Wednesday Meeting at 7:30 P. M.

OGLETHORPE
R. A. Coffield, 2219 E. 39th St., Savannah, Ga.
Second Friday, 8 P. M. Reddy Kilowatt Room, Savannah Electric and Power Company.

PADUCAH
J. B. Russell, Carbide & Carbon Chemicals P. O. Box 748, Paducah, Ky. Tel: 5-6311—Ext. 403
Second Tuesday Dinner at 6:30 P. M. Meeting 8 P. M.

PANHANDLE
R. L. Barnett, Box 1606, Amarillo, Texas
Third Tuesday, Dinner at 7:30 P.M. Phillips Grade School Cafeteria, Phillips, Texas

PERMIAN BASIN
Jack M. Ray, P.O. Box 1386, Odessa, Texas
Second Tuesday, Dinner at 8 P.M. Tel: 2-2813

PHILADELPHIA
A. S. Chatfield, c/o American Meter Company, 1513 Race St., Philadelphia 2, Pa.
Third Wednesday, Elks Club, 1330 Arch St., Dinner at 6:30 p. m., program at 7:30.

PITTSBURGH
Dr. A. H. Peterson, Mellon Institute, 4400 Fifth Ave., Pittsburgh 13, Pa. MA 1-1100
Fourth Monday, Dinner at 6:30 P.M., Meeting at 8:00 P.M., Roosevelt Hotel

PRESQUE ISLE
F. L. Moore, American Meter Co., 920 Payne Ave., Erie, Pa.
Fourth Tuesday, Meeting at 8:00 P. M.

RICHLAND
J. R. Plee, 1309 Roberdeau, Richland, Wash. Tel: 5-8692
Second Wednesday, Meeting at 7:30 P. M.

ROCHESTER
R. C. Schwarz, Jr., 1201 Granite Bldg., Rochester 10, New York. Tel: Hamilton 1468
Fourth Tuesday, Meeting 8 P.M. U. of R., Bausch & Lomb Physics Lecture Room 109.

SABINE-NECHES
R. A. Block, 2301 Avenue "G", Nederland, Texas
Last Tuesday, Meeting at 7:30 P. M., Orange County Courthouse, Orange, Texas.

SARNIA
L. J. Hall, 730 Talfourd St., Sarnia, Ont., Canada. Tel: EDgewater 2-3538
Fourth Monday 8:00 P. M. YM-YWCA

SAVANNAH RIVER
F. D. Reed, 516 Goldman St., North Augusta, South Carolina
Second Wednesday, Dinner at 7:30 P.M. North Augusta Legion Post.

SEATTLE
Frank S. Melder, 2439 76th N.E. Bellevue, Washington, Second Friday.

SOUTH TEXAS
Homer C. Givens, P.O. Box 637, Falfurrias, Texas. Tel: 202
First Thursday, Engineers Club

ST. LOUIS
W. G. Lee, 4710 Delor St., St. Louis 16, Mo. Tel: FL 8516.
First Wednesday After First Monday, Meeting at 8:00 P. M.

TOLEDO
Warren G. Myers, 2257 Upton Ave., Toledo 6, Ohio.
Third Tuesday, 8:00 P. M. Edison Service Bldg. W. Delaware Ave., Toledo, O.

TORONTO
John W. Huether, 311 Sutherland Dr., Lenside, Ontario, Canada. Tel: HU-7114
Fourth Thursday, Meeting at 8:00 P. M.

TULLAHOMA
Owedia A. Montgomery, ARO, Inc., GDF Instrument Branch, AEDC, Tullahoma, Tenn. Tel: 636
Second Tuesday, Meeting at 7:30 P. M.

TULSA
G. R. McDannold, 1203 E. 130th St., Tulsa, Okla.
First Monday, Meeting at 7:30 P.M.

TWIN CITIES
John L. Schmidt, 1879 University Ave., St. Paul 4, Minn., Tel: DR 0064
Fourth Tuesday, Dinner at 6:30 P.M., Meeting 7:30 P. M.

WASHINGTON
Edward C. Lloyd, 2105 Spencer Road, Silver Spring, Md. Tel: SH. 9340.
Third Monday, Meeting at 8:00 P. M.

WAYNE COUNTY
Clarence Ellison, 2443 15th St., Wyandotte, Michigan. Tel: Avenue 2-4178.
Third Monday, Meeting at 8:00 P. M.

WICHITA
J. W. Rieg, Koch Engineering Co., 123 S. Charles, Wichita 12, Kansas.
Third Thursday, 8 P. M. Scientific Bldg.

WILMINGTON
W. C. Ruglass, 900 A West 8th Street, Wilmington, Delaware
Second Tuesday, 8:00 P. M. Harlan School.

ISA NEWS

First Vice President's Report

During the past year the Recommended Practices Committee has been active in the following fields:

D. M. Boyd

1. Last November it sponsored the second joint Instrument Users and Manufacturers Meeting. This meeting was very successful and covered such subjects as standardization of Instrument ranges, coding cut-out dimensions, charts, valve characteristics and methods of marking and calibrating control characteristics.

2. Two new Recommended Practices subcommittees were organized, one on "Positive Displacement Metering" and one on "Preferred Instrument Cut-out Dimensions". The subcommittee on cut-out dimensions has made a composite drawing showing the present dimensions of most miniature instruments. This information has been instrumental in influencing some of the instrument companies to adopt a case for their new instruments which fits into the preferred size used by other instrument companies.

3. Several Recommended Practices have been published or are ready to be published. They are: RP11.1, "Mercury Handling", published; RP7.1, "Pneumatic Control Circuit Pressure Test", ready for publication; RP2.1, "Manometer Tables", Standard changed from "Tentative Recommended Practice" to "Recommended Practice", published; RP1.2, "Thermocouple and Thermocouple Extension Wire Installation"; RP1.3, "Thermocouple and Thermocouple Extension Wire"; RP1.4, "Fabrication of Thermocouples; and RP1.5, "Thermocouple Checking Procedure", published as "Tentative Recommended Practices".

4. Questionnaires on several subjects have been sent out and reports will be available at the next meeting of the Recommended Practices Committee.

5. The Subcommittee on Hazardous Wiring has worked with the National Fire Protection Association and as a result several changes have been made in the National Electrical Code.

D. M. Boyd,
First Vice President

ASME-IRD Plan Frequency Response Symposium

Due to considerable interest by instrumentation engineers on the subject of frequency response analysis, the American Society of Mechanical Engineers has arranged a two-day Symposium on this subject as a part of the Annual Society Meeting in New York City Dec. 1 & 2, 1953. Papers on practical applications and theory will be presented by recognized American and European authorities.

Of special interest to process instrumentation and control engineers are papers on the application of frequency response to process control problems and a survey paper describing pneumatic sine wave generators used for process and device testing. The practical aspects of frequency response techniques and some simple criteria for their use will also be presented for those interested in the techniques as a simple aid to practical experience. Other papers will cover recent developments in the linear and non-linear control theory. For further information on the Symposium, contact: Stephen P. Higgins, Jr., Minneapolis-Honeywell Regulator Co., Brown Instruments Division, Wayne and Roberts Ave., Phila. 44, Pa.

EMPLOYMENT SERVICE

Forward your letter to ISA
1319 *Allegheny Ave.,*
Pittsburgh 33, *Pa.*

SALES ENGINEERS. Openings available with large industrial instrument manufacturer for field Sales Engineers in New York, Chicago, Pittsburgh, Houston, and St. Louis areas. Graduates of recognized engineering colleges with training in electronics preferred. Mechanical and Chemical Engineers will also be considered. Excellent opportunity for young engineers with sales aptitude who wish to enter the fast-growing industrial instrument field with a long established and rapidly growing manufacturer of industrial instruments. Box 851.

ELECTRONIC ENGINEER. Progressive Midwest Manufacturer has immediate opening for young Engineer, 25-35, who has had research experience on automatic controls. Should develop into product designer of electronic and electro mechanical equipment. Attractive salary. Send resumes to Box 852.

INSTRUMENTATION ENGINEERS. B. S. or M. S. in E. E.; knowledge of electronics, servomechanisms and general instrumentation is most desirable whether obtained academically or through work experience. Work involves assistance and consultation in connection with aerodynamic and thermodynamic research projects. Applicants must possess initiative and aptitude for original thinking. Excellent working conditions in central Connecticut. Box 853.

INSTRUMENT DESIGNER. Engineering degree not mandatory; must have about two years' drafting experience in small mechanisms and a knowledge of electronics. Work consists primarily of preliminary layouts of wind tunnel mechanisms including balances, and detailed electronic and servo layouts for small shop. Excellent working conditions in central Connecticut. Box 854.

INSTRUMENT TECHNICIAN. Technician to maintain instrumentation for new fundamental research laboratory devoted to the physics and chemistry of metal cutting processes. Familiarity with electronics circuits encountered in thermometry, strain gauging, radiation counting and spectroscopy desired. Location—Ohio. Box 855.

INSTRUMENT MECHANICS. At least 2½ years experience in repairing, calibration and installation of mechanical and electronic instruments and controls for chemical plant operation. Rate: Up to $2.25 per hour. Location—Illinois. Box 856.

INSTRUMENT MECHANIC. Temperature, flow and miscellaneous instrument and measurement applications in rotary kiln plant. Several kilns in plants in Thornton and South Chicago, Illinois. At present not full time but to be supplemented by electrical installation and maintenance work, interesting and varied work with opportunity for right man. Salary open. Box 857.

INSTRUMENT ENGINEER. Position requires a graduate engineer with experience in aircraft engine instrumentation. Our engine test facility is used for development testing of turbojet and ramjet engines under a simulated altitude conditions. Location—Tennessee. Box 858.

ELECTRICAL OR ELECTRONIC ENGINEER. Position requires graduate engineer with experience in computer design, development and maintenance or pulse circuit techniques, radar, and high frequency communications. Opening is in our technical services division and will lead to supervision of section devoted to operational servicing of all company computers. Location—Tennessee. Box 859.

INSTRUMENT ENGINEERS. Positions require graduate engineer with experience in wind tunnel instrumentation. The work includes the direction of the installation of pressure, temperature, force, dew point, and position measuring devices and optical and television equipment employed in wind tunnel instrumentation. Location—Tennessee. Box 860.

INSTRUMENT ENGINEER. Position requires graduate engineer with experience in wind tunnel instrumentation. The opening is in our gas dynamics facility, which consists of a group of wind tunnels used for developmental testing of models of air craft, projectiles and missiles. Location—Tennessee. Box 861.

PHYSICIST. Position requires formal training in optical physics and experience in optics. Opening is in the technical services division and will lead to supervision of section to be devoted to organization and operation of a central optical laboratory and operation of a central photographic laboratory. Location—Tennessee. Box 862.

SALES ENGINEERS. Requirement is for top notch mechanical or chemical engineers. Preferably not over 35 years of age who after an intensive but brief training period can be prepared for important sales engineering assignments. These men should be completely sales minded and have sufficient engineering background to handle a highly technical product with contacts to be made with top notch engineers of the country's foremost process industries. Salaried position and excellent benefits. Location—Pennsylvania. Box 863.

RESEARCH SUPERVISOR. For instrumentation research section with B.S. or higher in Engineering or Physics. Three years or more experience in industrial instrumentation with a record of one or more successful instrumentation developments. Will supervise the design and development of special instruments and controls for research

Continued on page 1723

SCENES AT THE EIGHTH ANNUAL CONFERENCE AND EXHIBIT

Speakers Table at the ISA Members Luncheon

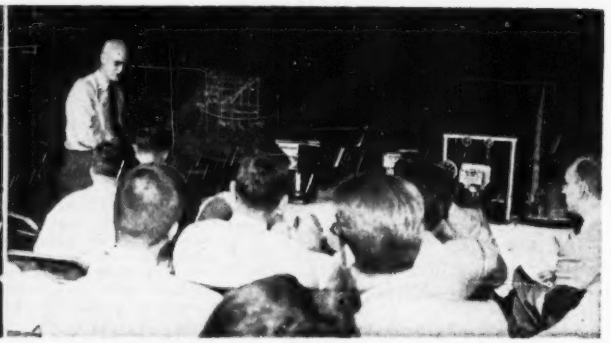
Wednesday night party featured top-notch acts and standing room only.

Instrument Industry luncheon in the Morrison Hotel's Terrace Casino.

New ISA Booth in the Sherman Lobby.

Ladies Tea was well attended.

Panel Discussion "Instrumentation in Research and Development."



M. R. Hall of Foxboro Company has complete attention.

W. A. Wildhack, Anne Montgomery and Fred Lennon at the President's Reception.

F. Trapnell greets Warren Brand at President's Reception.

EMPLOYMENT

Continued from page 1721

in and production of steel. Salary open. Location—Pittsburgh, Penna. Box 864.

ELECTRONICS ENGINEER for instrumentation research section. B.S. or higher in Electrical Engineering or Physics. Will design and construct electronic apparatus used in conjunction with steel making research and production controls. Salary open. Location—Pittsburgh, Penna. Box 865.

INSTRUMENT ENGINEER. Preferably with engineering degree, to design instrument systems for organic chemical processing plant. Work to include installation and supervision of the maintenance of such systems. Location—Midwest. Box 866.

SALES ENGINEER. We need a man to cover the New Jersey territory on controls, relief devices, pressure vessels and processing equipment. Requires technical education or experience in sales. Must be qualified to discuss our products with engineers of the chemical and refining industries and engineering companies. Box 867.

ELECTRONIC ENGINEERS—Degrees of B.A. or M.S. in E.E. or equivalent. At least 5 years experience of circuit design in connection with the mass production of TV tuners (ideal) HF, or TV receivers of HF equipment. Designer of military or Police Transceivers, FM Broadcast receivers, IFF equipment, Radar Receivers, (VHF & UHF front ends similar VHF and UHF equipment may be acceptable.) Must be familiar through actual construction calculation and measurements on stage gains, noise factor, etc., for amp. stages, oscillators and converters; must have knowledge of commercial components, specifications and measurements; must have knowledge of engineering problems closely associated with production and have been project engineer on major projects. Location—Indiana. Box 868.

ELECTRONIC ENGINEERS—Degrees of B.A. or M.S. in E.E. or equivalent. At least 5 years experience of circuit design in connection with the mass production of TV tuners (ideal) HF, or TV receivers of HF equipment. Designer of military or Police Transceivers, FM broadcast receivers, IFF equipment, Radar Receivers, (VHF & UHF front ends & IF systems), & certain test equipment designers working on TV or similar VHF and UHF equipment may be acceptable. Must be familiar through actual construction calculation and measurements on stage gains, noise factor, etc., for amp. stages, oscillators and converters; must have knowledge of commercial components, specifications and measurements; must have knowledge of engineering problems closely associated with production and have been project engineer on major projects. Location—Indiana. Box 869.

PHYSICIST—For new Physics and chemistry group to work on Metal cutting processes. Experience with x-ray ultra-violet and infra-red spectroscopy, electron microscopy, or plastic deformation of metals desirable. Location—Ohio. Box 870.

RESEARCH ENGINEER—B.S., M.E. or equivalent. New graduate or one to two years experience, to do research on mechanical problems or control problems in connection with pneumatic and electric control instruments and systems. Location—Chicago. Box 871

ELECTRONIC PROJECT ENGINEER—B.S. or E.E. or equivalent. Three to ten years experience in research or design on electronics projects with supervisory ability. Will design electronic devices as related to control instruments. Location—Chicago. Box 872.

DESIGN ENGINEERS (2) B.S., M.E. or equivalent. Three to ten years experience in the design of small mechanisms and control devices. Location—Chicago. Box 873.

TEST ENGINEER—B.S., M.E. or equivalent. New graduate or one year's experience. Will handle application problems related to control instruments. Location—Chicago. Box 874.

TEST ENGINEER—B.S., E.E. or equivalent. Some electronic experience desirable. Will conduct tests on mechanical and electronic control devices. Location—Chicago. Box 875.

MANUFACTURER'S REPRESENTATIVES for Automatic Temperature & Pressure control valve manufacturer. Mechanical instrumentation experience required. Exclusive sales contract. Good commission. Location—Ohio. Box 876.

PYROMETER ENGINEER who must be qualified to handle technical correspondence, figure inquiries, make up quotations, write good business letters and handle telephone inquiries. Applicant must be between age 27 and 45 years and absolutely must have had prior experience in this field and a university graduate. Salary open. Location—Illinois. Box 877.

INSTRUMENT ENGINEERS with seven to ten years experience in all phases of process instrument maintenance to assist in the solution to application, maintenance and Instrument Development problems. Location—Ohio. Box 878.

INSTRUMENT ENGINEER—Engineering or physics degree. Minimum two years' experience in guided missile or aircraft flight test instrumentation desirable. Other instrumentation background will be considered, such as jet engine testing. Age open. Salary range $6000 to $9000. Location—Michigan. Box 879.

DATA ANALYSIS SUPERVISOR—Engineering, physics, or mathematics degree. Minimum two years' experience in date analysis and reduction of oscillograph, camera, and various type recorder records. Field crew assignment in Maryland. Home office in Michigan. Age open. Salary $6000 to $8000 per year. Box 880.

PHYSICISTS—Engineering or Physics degree. Minimum two years' experience in electronic circuit design. Advance degree considered in partial fulfillment of experience. Must have a talent for designing circuits and "gadgeting" simple devices to properly hook up standard electronic laboratory equipment to perform special test work. Age open. Salary $6000 to $9000. Location—Michigan. Field test site in Maryland. Box 881.

ELECTRONIC ENGINEERS—Engineering or Physics degree. Minimum two years experience in electronic circuit design. Advance degree considered in partial fulfillment of experience. Must have a talent for designing circuits and "gadgeting" simple devices to properly hook up standard electronic laboratory equipment to perform special test work. Age open. Salary $6000 to $9000. Location—Michigan. Field test site in Maryland. Box 882.

RECENT GRADUATE—Master of Science degree in Electrical Engineering or Physics with minor in Electronics. Pre-college technician experience desirable, but not essential. Work on electronic circuit design associated with instrumentation and testing of special equipment. Salary open. Location—Michigan. Box 883.

DATA ANALYST—Master of Science degree in Mathematics, Physics, or Engineering. Workable knowledge of calculus, differential equations, fourier series, and vector analysis. Interest in technical writing desirable. Salary open. Location—Michigan. Box 884.

EQUIPMENT and INSTALLATION ENGINEER—Graduate engineer with at least five years' experience in plant engineering or equipment engineering which should include experience with maintenance and calibration of instruments; at least two years of supervisory experience. Maintenance of instruments; calibration of instruments; installation of instruments according to test specifications preparatory to testing; requisitioning, receiving, marking, storing, and recording of instruments and equipment. Responsible for accountability records, responsible for making shipment systematically from Saginaw, Michigan to the test site. Salary to $8500. Box 885.

INSTRUMENT ENGINEER—Graduate engineer with at least 3 years' experience in taking test data preferably from high speed recording instruments. Advanced engineering degrees will be considered as a partial substitute for experience requirement. Observes operation of test and checks operation of instruments to which he is assigned by Test Operating Engineer. Records data as required, and collects charts and records from instruments to which he is assigned. Assists in compiling data and in processing reports. Assists in calibrating, repairing or installing instruments. Makes layouts or details of instrument attaching fixtures. Salary to $8000. Box 886.

INSTRUMENT MAINTENANCE AND CALIBRATION TECHNICIANS (2) One to two years' experience in maintaining and calibrating high speed recording instruments and installing same. Maintain instruments in operating condition and calibrate same ready for test. Install instruments as directed. Salary to $5500. Box 887.

INSTRUMENT MECHANIC—for work in paper mill. Consists of inspecting, testing, repairing, adjusting and calibrating service instruments including actuating connections and control equipment. Instruments are electrical, mechanical, pneumatic, hydraulic, thermal or any combination of these. $2.34 per hour, 40 hour week. Vacation and retirement benefits. Location—Florida. Box 888.

INSTRUMENT MECHANIC—To install, repair and maintain pneumatic control systems for process and boiler room. Rate to $2.50 per hour. Steady employment. Company benefit plans include liberal pension, vacation, sick benefit, profit sharing and guaranteed income. Location—Chicago, Ill. Box 889.

APPARATUS PRODUCTION ENGINEER—Western manufacturer desires graduate engineer with 5 to 7 years of practical apparatus production experience. Must be able to engineer designs and models of electrical, optical and electromechanical devices for production; be familiar with precision machine-tools, with foundry and die-casting methods, plastic molding, press forming, finishing processes and electronic assembly, and be able to design tooling and set production quantities consistent with economy, demand and timing. Opportunity of advancing to position of head of Production Planning Department for individual with good background, cooperative disposition and good personality. Attractive working and living conditions. Send full particulars with details of training. Box 890.

PLANT INSTRUMENT ENGINEER to direct the activities of the plant instrument maintenance group and to make recommendations for process control improvement. Require graduate engineer with 3 to 5 years plant experience for Eastern North Carolina pulp and paper mill. Salary open. Box 891.

SALES ENGINEER—Baltimore, Maryland and vicinity, also Richmond, Virginia and entire state. Mechanical or electrical background with or without instrument experience. Will consider sales trainee. Salary and expenses first year plus profit share thereafter. Must have car. To join long established organization of distributors of industrial controls and instruments. Box 892.

MANUFACTURER'S REPRESENTATIVE—Sales engineer or sales engineering organization to cover Chicago and surrounding states. Product: Ultra low torque potentiometer of extreme precision. Used in recording and control instrumentation, computers, servo mechanisms. Box 893.

ELECTRONIC ENGINEER—B.S. in Electrical Engineering or equivalent. Some experience in design of DC amplifiers, analog computers, or control circuits desirable. Work not routine. Good opportunity for the younger man. Location—Illinois. Box 894.

ELECTRONIC INSTRUMENTATION—Research and development position in laboratory of medium sized, well established manufacturer of analytical instruments for chemical and clinical field. Familiarity with electronic circuitry desirable. Permanent position. Age under 40. Midwest. Salary depends on what you can offer. Box 895.

TECHNICAL SECRETARY—Woman, college graduate in science preferred. Age not a factor. Able to handle all phases of clerical work connected with research department of long established, medium sized, midwest manufacturer of precision analytical instruments. Typing and simple filing necessary, ability to write technical material desirable, not essential. Permanent. Salary open. Box 896.

CHEMICAL ENGINEER—or chemist under 40 with drive for research and development projects. Will lead to supervisory position for right man. Permanent. Long established, medium sized, midwest manufacturer of precision analytical instruments. Salary depends on what you can offer. Box 897.

INSTRUMENT MECHANIC with experience on Brown temperature controllers and recorders. Average age 25 years. Location—Indiana. Box 898.

DEVELOPMENT AND DESIGN ENGINEERS—Product group lead men or manufacturing experience. One to be responsible for engineering of pneumatic controllers. One responsible for level, specific gravity and other measurement primaries: and one to be responsible for flow measuring devices. Excellent salaries, benefits and growth potential. Location—Pennsylvania. Box 899.

APPLICATION ENGINEER—Requirement is for top notch pneumatic control specialist. Preferably not over 35 years of age, who after an intensive but brief training period will qualify as this company's home office chief application engineer in this field. This position must be filled by a sales minded man with sound instrument engineering background who is looking for a real opportunity to utilize his capabilities to their fullest extent with a progressive growing company. Salaried position and excellent benefits. Location—Pennsylvania. Box 900.

INSTRUMENT MECHANIC experienced in chemical or oil industry. Must be able to repair and service all types of recording and control instruments, including Leeds & Northrup, Foxboro, Taylor, Brown, also electronic type potentiometers. Working knowledge of pneumatic control systems as applied to process control, differential type metering systems and control valves. Location—Ohio. Box 901.

INSTRUMENT MECHANIC—First class. Requirements—several years' experience with chemical plant or oil refinery. Must be familiar with all general types. High school graduate preferred. Location—Louisiana. Box 902.

National Committees & Chairmen

Society Structure & Planning—Nelson Gildersleeve
Nominating—Ralph D. Webb
Constitution, Rules and Procedures—R. L. Galley
Instrument Industry—Charles L. Saunders
Finance—G. R. Feeley
Meetings & Exhibits—E. J. Grace, Jr.
Publications—C. W. Covey
Sections & Memberships—M. S. Jacobs
Employment—P. V. Jones, Jr.
Intersociety Relations—J. C. Peters
Public Relations—Douglas M. Considine
Government Relations—Ralph L. Goetzenberger
Educational—Prof. Robert J. Jeffries
Historical—L. M. Susany
Technical Program—E. G. Eskin
***Research and Development**—Chairman to be selected
Instrument Operation and Maintenance—J. Johnston, Jr.
Testing Instrumentation—D. C. Little
Analysis Instrumentation—Dr. Axel H. Peterson
Instrumentation for Inspection and Gaging—Thomas W. Marshall, Jr.
Instrumentation for Production Processes—C. A. Hansen, Jr.
Instrumentation for Transportation—John J. McDonald
Medical Instrumentation—Dr. H. J. Morowitz
Meteorological Instrumentation—Christos Harmantas
Radiation Instrumentation—Richard W. Johnston
Geophysical Instrumentation—S. Kaufman
Physical Properties Measurement—Prof. H. C. Roberts
Aeronautic Instrumentation—Robert Tozier
Data Handling—E. W. Burdette—R. P. Wehrle
Recommended Practices—A. V. Novak

PUBLICATIONS FOR SALE

The following ISA Tentative Recommended Practices and Proceedings are for sale and may be ordered from the National Office, 1319 Allegheny Avenue, Pittsburgh 33, Pa.

ISA RECOMMENDED PRACTICES

No.	*Title*	*Date Published*	*Unit Price**
RP1.1	"Coding of Thermocouple Wire and Extension Wire"	2-1-53	.50c members 1.00 others
RP2.1	"Manometer Tables"	1-19-49	1.00 members 2.00 others

ISA TENTATIVE RECOMMENDED PRACTICES

RP1.2	"Thermocouples and Thermocouple Extension Wires—Installation"	8-22-52	.50c all
RP1.3	"Thermocouples and Thermocouple Extension Wires—Terminology; Limits of Error; Wire Sizes"	8-22-52	.50c members 1.00 others
RP1.4	"Thermocouples—Fabrication"	8-22-52	.50c all
RP1.5	"Thermocouples—Checking Procedures"	8-22-52	.35c all
RP3.1	"Flowmeter Installations Seal and Condensate Chambers"	5- 1-51	.50c all
RP4.1	"Uniform Face to Face Dimensions For Flanged Control Valve Bodies"	1-15-51	.25c all
RP5.1	"Instrument Flow Plan Symbols"	6-26-50	1.00 all
RP11.1	"Mercury Handling"	4-16-52	.50c all
1950	Proceedings		2.50 members 5.00 non members
1951	Proceedings		2.50 members 5.00 non members
1952	Proceedings		5.00 members 10.00 non members

*Quantity prices will be supplied on request.
(7-52)

Electrical Techniques for Time Lag Compensation of Thermocouples Used in Jet Engine Gas Temperature Measurements

By CHARLES E. SHEPARD* and I. WARSHAWSKY*

Abstract. Basic electrical networks are described that compensate for the thermal time lag of thermocouples used in research on jet engines. The measurement or the detection of rapid temperature changes by such thermocouples can thereby be improved. In addition to the simple resistance-capacitance compensator, a novel transformer-type compensator is presented.

The completeness of the compensation is dependent upon the knowledge of the magnitude of the thermocouple time lag. Several methods for the calculation or the measurement of this time lag are presented.

Several compensating systems and their application to specific temperature-measuring problems are described. These systems use standard commercial amplifiers and recorders.

THE testing of jet engines and the fundamental study of the component compressors and turbines involve the measurement of fluctuating gas temperatures. When a thermocouple is used for these measurements, the thermal time lag, caused by the slow rate of heat transfer between the thermocouple and the surrounding gas, limits the ability of the thermocouple to follow the gas temperature fluctuations. The thermal time lag is such that the amplitude of the fluctuations indicated by the thermocouple decreases as the frequency of the fluctuations increases.

Time Response of Bare-Wire Thermocouple

The time response of a bare-wire thermocouple can be described by the following differential equation[1]:

$$\tau \frac{dT_w}{dt} + T_w = T_g \qquad (1)$$

where T_w is the thermocouple temperature, T_g is the temperature of the gas stream, and the time constant τ defines the ability of the thermocouple to follow the gas temperature variations. The value of τ depends upon the geometry and size of the thermocouple and upon the gas flow conditions.

In terms of step-function response, τ is the time required for the thermocouple output to cover 63 per cent of the total change, as shown in Fig. 1a. In the frequency-response curve (Fig. 1b), showing the response to a sinusoidal temperature variation (Fig. 1c), the frequency at which the amplitude-ratio (thermocouple temperature/gas temperature) is down by a factor of $1/\sqrt{2}$ is called the *cut-off frequency* and is equal to $1/(2\pi\tau)$. Thus, a thermocouple having a time constant of 1 second will have a cut-off frequency of 0.16 cps.

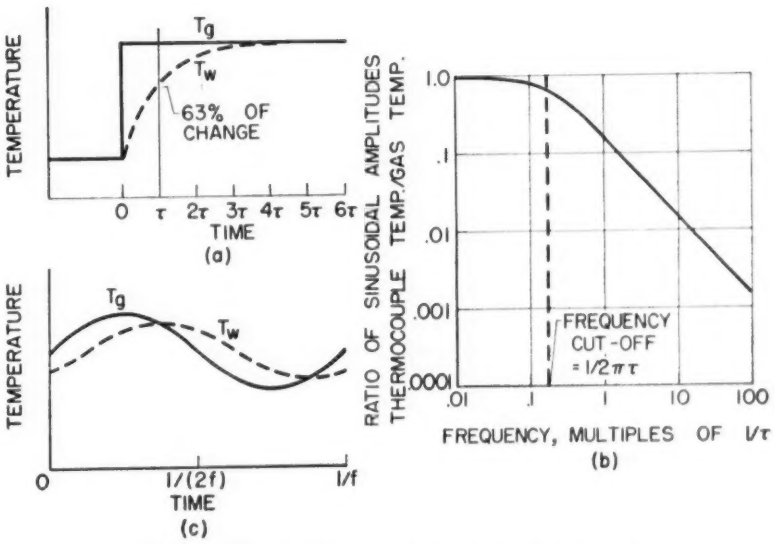


Fig. 1. Response of thermocouple to step and steady-state sinusoidal gas temperature changes.

Table I shows the range of time constants encountered in jet engine research, when butt-welded, bare-wire thermocouples are used. These values are calculated from data by Scadron and Warshawsky[1], by means of the formula

$$\tau = 58 \frac{(\rho c)_w}{(\rho c)_{Pt,0}} \left(\frac{519}{T_g} \right)^{0.18} \frac{\sqrt{D'}}{\sqrt{Mp}} \qquad (2)$$

where

ρ is density

c is specific heat

T_g is average gas temperature in degrees Rankine

D is wire diameter in inches

M is Mach No.

p is static pressure in atmospheres

subscript w refers to the thermocouple wire

subscript $Pt,0$ refers to platinum at 519° R.

Equation 2 applies for air in the Mach number range 0.1 to 0.9 and the Reynolds number range (based on wire diameter) 250 to 30,000. Values of the average value of $(\rho c)_w/(\rho c)_{Pt,0}$ at room temperature, for common thermocouple pairs, are

Pt, 13% Rh-Pt	1.02
Chromel-Alumel*	1.45
Chromel-Constantan	1.31

*Trademark registered Hoskins Corp.

*National Advisory Committee for Aeronautics, Lewis Flight Propulsion Laboratory, Cleveland 11, Ohio.

TABLE I. TIME CONSTANT, IN SECONDS, OF BUTT-WELDED, BARE-WIRE CHROMEL-ALUMEL THERMOCOUPLES

M	p (atm)	Diameter, in.			
		0.003	0.010	0.020	0.040
0.3	0.3	0.05	0.3	0.8	2
	1.0	0.03	0.2	0.5	1
	0.3	0.03	0.2	0.5	1.5
	1.0	0.02	0.1	0.3	1

Iron-Constantan	1.25
Copper-Constantan	1.23

Need for Lag Compensation

Although the time constants given in Table I for the butt-welded, bare-wire thermocouples are small compared to the time constants of most other types and are low enough for many applications, certain other applications require a still smaller time lag. In these rather special cases, it is necessary to use electrical methods of lag compensation[3]. Although it might be possible to use a thermocouple of sufficiently small wire diameter to give adequately rapid response for a given application, the very small wire sizes, such as the 3-mil size shown in Table I, present a definite problem in handling and installation and already represent a considerable compromise in favor of speed of response over such factors as mechanical strength and ease of fabrication.

Fine wire thermocouples under 10 mils must generally be fabricated and installed by especially trained personnel, and the service life may be very short. In view of the difficulties encountered in the use of fine wire thermocouples, it is often desirable to use larger, more rugged thermocouples and to use electrical time lag compensation to reduce the effective time constant, and thus to provide the necessary rapid response.

If the temperature changes are not extremely large, no appreciable non-linearity of Equation *1* is produced by the dependence of τ upon gas temperature, since the exponent of temperature in Equation *2* is so small. Non-linearity occurs only to the extent that the quanitity $\sqrt{Mp}$ varies synchronously with temperature.

In general, however, it is possible to assume an average value of the thermocouple time constant and to consider the differential Equation *1* as linear. Then, since the output of the thermocouple is a voltage, it is possible to use simple linear electrical networks to compensate for the imperfect response of the thermocouple and thus to permit measurement of rapidly changing temperatures with improved fidelity. Compensation of this type has been used in hot-wire anemometers[4,5].

Two of the basic types of compensators, the resistance-capacitance (R-C) type and the transformer-type, their characteristics and limitations, and the typical compensating systems in which they are used, are discussed in this paper.

Principles of Compensation

From the frequency response curve of the thermocouple, shown by the dotted lines in Figs. 2a and 2b, it is seen that the response drops off at frequencies greater than $1/2\pi\tau$ (the cut-off frequency of the thermocouple). Suppose it is desired to measure gas temperature variations at frequencies higher than the cut-off frequency. If a compensating network is used which has a response that is the inverse of that of the thermocouple, over a certain frequency range, then the combined response will be flat over that frequency range.

A system having such a frequency response will also more faithfully reproduce any other type of gas temperature change. For example, if the frequency response is extended by a certain factor F (so that the cut-off frequency of the thermocouple-compensator combination is $F/2\pi\tau$), the time required to complete 63 per cent of a step change will be reduced by F, and the thermocouple-compensator combination will act as though it had an effective time constant τ/F.

The compensator achieves this improvement in response by performing the operations indicated by the differential equation; that is, it adds a signal proportional to the time rate of change of the thermocouple temperature to a signal proportional to the thermocouple temperature, and thereby yields a signal proportional to the gas temperature. The proper constants of proportionality are obtained by suitable choice of the circuit constants.

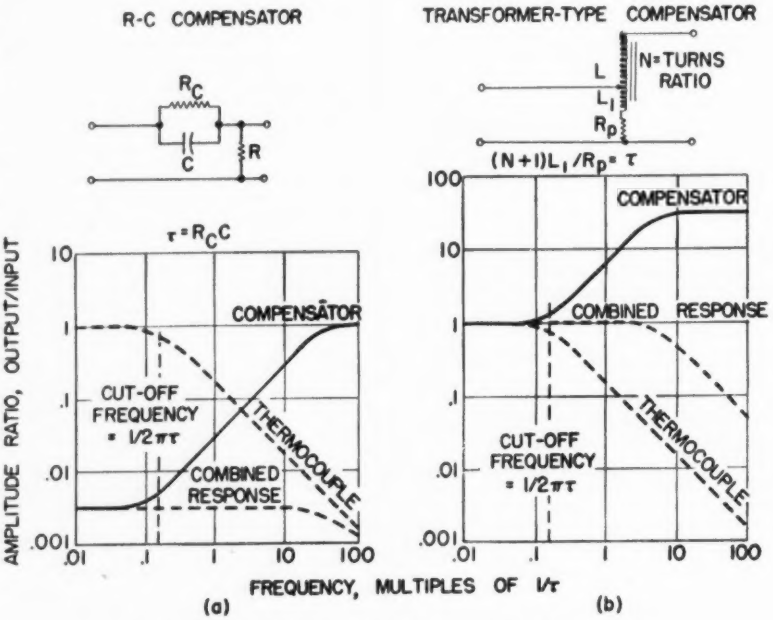


Fig. 2. Basic compensators and their response characteristics.

R-C Type Compensator

In the R-C compensator of Fig. 2a, the summation is obtained by choosing R and C so that a current flows through R that is approximately proportional to the time rate of change of the thermocouple temperature, and by choosing R_c to produce an additional current through R which is proportional to the thermocouple temperature. The voltage drop produced by the sum of the two currents

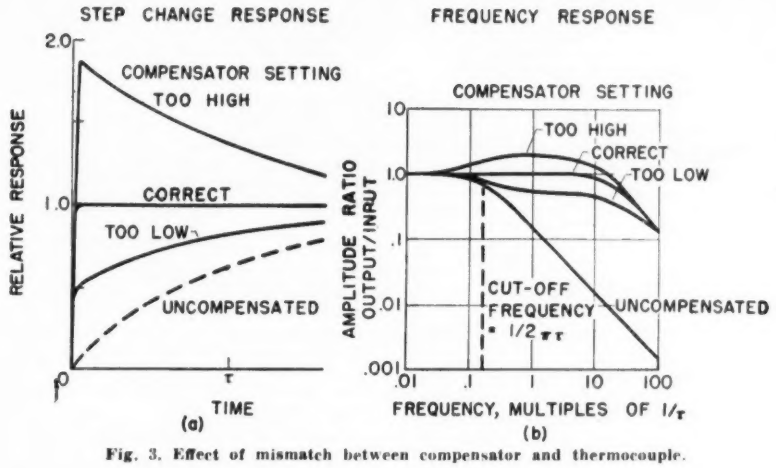


Fig. 3. Effect of mismatch between compensator and thermocouple.

flowing through R is then approximately proportional to the gas temperature.

The criterion for achieving proper compensation is

$$R_c C = \tau \qquad (3)$$

Because of the large range of capacitance and resistance values that are readily available, there is no practical limit on the maximum value of time constant which can be compensated with the R-C network.

When the R-C compensator is connected to a low-resistance thermocouple and to a high-resistance load, the criterion for extending the original cut-off frequency by a factor F (and thereby achieving an effective time constant τ/F) is

$$1 + (R_c/R) = F \qquad (4)$$

Equations *3* and *4* are the basic equations of the idealized R-C compensator. They serve to establish the relationships between R, R_c, and C in terms of the time constant τ to be compensated and the desired response improvement factor F.

As can be seen in Fig. 2a, the price of improving the response by a factor F is a reduction in signal level by this same factor. Thus, although the R-C compensator is capable of a very large reduction in effective time constant, the corresponding attenuation which can be tolerated in any practical case will limit the extend of compensation. The effect of this attenuation will be discussed more fully later in this paper.

Transformer-Type Compensator

The other basic type of compensator is the transformer-type shown in Fig. 2b. This compensator uses an ordinary well-shielded audio transformer having a high turns-ratio. Suitable choice of the elements R_p, the primary circuit resistance, L_l, the primary inductance, and N, the turns-ratio, can produce a secondary voltage approximately proportional to the rate of change of the thermocouple temperature. Since the auto-transformer connection also provides a signal proportional to the thermocouple voltage, the proper summation required by the differential Equation *1* can thereby be obtained.

The criterion for achieving proper compensation is

$$(N+1)L_l/R_p = \tau \qquad (5)$$

The adjustment is generally made by changing R_p; however, for effective compensation, the load on the compensator must be of a resistance larger than N' times the primary circuit resistance.

When the transformer-type compensator is connected to a low-resistance thermocouple and to a high resistance load, the original cut-off frequency is extended by a factor F given by

$$N + 1 = F \qquad (6)$$

where N is the turns ratio, and the effective time constant of the combination becomes τ/F.

Equations *5* and *6* are the basic equations of the idealized transformer-type compensator.

When it is desired to use commercially available transformers to compensate for very small thermocouple time constants, it is often found that the required value of R_p is impractically high, because the load resistance then required ($>>N'R_p$) is too high. In such cases, the expedient may sometimes be used of partially saturating the transformer core by a d-c current through a separate winding, thereby reducing the value of L_l.

As can be seen in Fig. 2b, the advantage of the transformer-type compensator lies in the fact that the compensation is achieved without an ap-

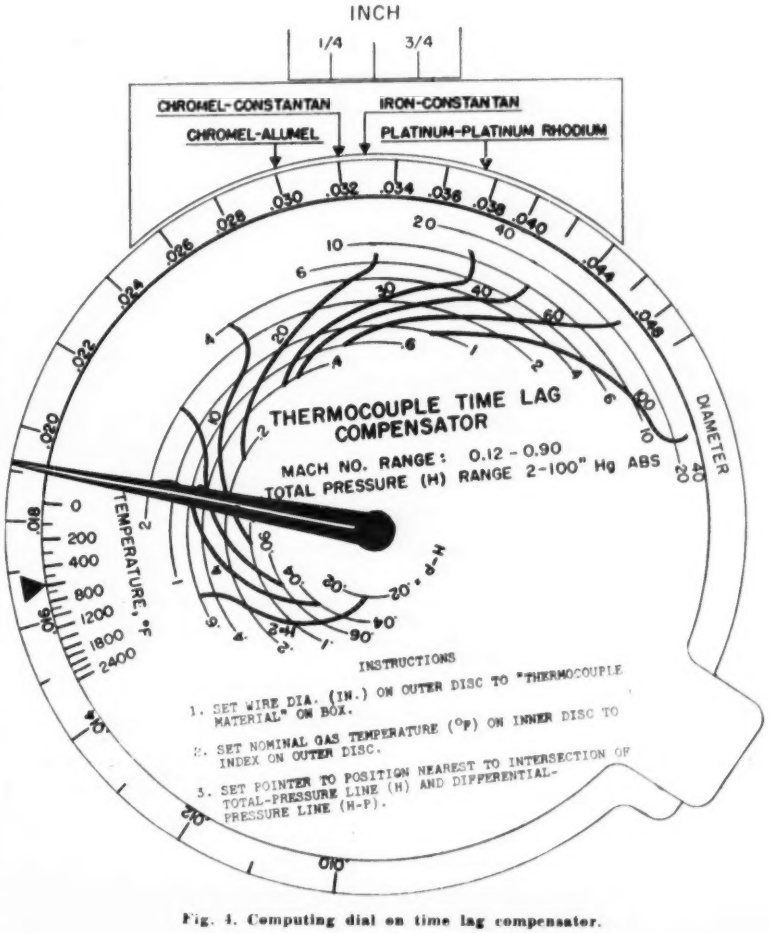

INCH
1/4
3/4
CHROMEL-CONSTANTAN
CHROMEL-ALUMEL
IRON-CONSTANTAN
PLATINUM-PLATINUM RHODIUM
THERMOCOUPLE TIME LAG
COMPENSATOR
MACH NO. RANGE: 0.12 - 0.90
TOTAL PRESSURE (H) RANGE 2-100" Hg ABS
DIAMETER
TEMPERATURE, °F
INSTRUCTIONS
1. SET WIRE DIA. (IN.) ON OUTER DISC TO "THERMOCOUPLE MATERIAL" ON BOX.
2. SET NOMINAL GAS TEMPERATURE (°F) ON INNER DISC TO INDEX ON OUTER DISC.
3. SET POINTER TO POSITION NEAREST TO INTERSECTION OF TOTAL-PRESSURE LINE (H) AND DIFFERENTIAL-PRESSURE LINE (H-P).

Fig. 4. Computing dial on time lag compensator.

preciable attenuation of the voltage signal, provided a high input resistance recorder and a low resistance thermocouple are used. The requirement that the load on the transformer-type compensator be of very high impedance greatly reduces the power which can be drawn from the thermocouple. Thus, compensation is achieved without voltage attenuation, but is accompanied by very large power attenuation.

This compensator does not permit a reduction in effective time constant much greater than 50 in most practical situations. In addition, the maximum time constant which can be compensated using ordinary commercial transformers is limited by the maximum value of $(N+1)L_i/R_p$, which is generally of the order of several seconds. The larger the transformer, the higher the value of time constant that can be compensated.

Off-Design Characteristics

The response curves for the compensator - thermocouple combinations, as shown in Fig. 2, are based on the assumption that the compensator is properly adjusted to match the thermocouple time constant. The value of the thermocouple time constant is a function of the velocity and the density, (or equivalently, the Mach number and the static pressure) of the gas stream. Since these gas properties change with operating conditions, the knowledge of the time constant is subject to some uncertainty.

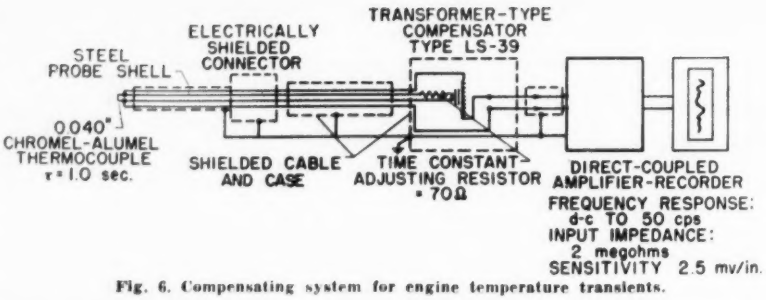

STEEL PROBE SHELL
ELECTRICALLY SHIELDED CONNECTOR
TRANSFORMER-TYPE COMPENSATOR TYPE LS-39
.040" CHROMEL-ALUMEL THERMOCOUPLE τ = 1.0 sec.
SHIELDED CABLE AND CASE
TIME CONSTANT ADJUSTING RESISTOR • 70Ω
DIRECT-COUPLED AMPLIFIER-RECORDER
FREQUENCY RESPONSE: d-c TO 50 cps
INPUT IMPEDANCE: 2 megohms
SENSITIVITY 2.5 mv/in.

Fig. 6. Compensating system for engine temperature transients.

In practice, therefore, a certain amount of mismatch may exist between the thermocouple time constant and the compensator. The effect of this mismatch can be characterized by the response of the system to step and to sinusoidal gas temperature changes. In Fig. 3a, it can be seen that the response to a step change shows overshoot when the compensator is set at too high a value of time constant, and undershoot when set too low.

In the frequency-response curves of Fig. 3b, the effect of mismatch is seen to destroy the over-all flatness of the curve, although there may still be a limited range of flat frequency response beyond the original cut-off frequency. When the compensator is set for too high a value of time constant, the amplitude of the output signal is too large; when the compensator is set too low, the amplitude of the output signal is too small. These effects of mismatch are treated in greater detail in reference 2.

Determination of Actual Time Constant

Because the mismatch between the thermocouple time constant and the compensator setting restricts the usefulness of the compensating system, methods which can be used to determine the thermocouple time constant under actual operating conditions will be discussed.

(1) If a butt-welded, bare-wire thermocouple is used, and the gas flow conditions are known, Equation 2 can be used to compute the time constant. A nomograph[1] based on this formula can be used to compute τ. This nomograph can be converted into a slide-rule type computing dial on the compensator (Fig. 4) so that, when the index knob is turned to the values of gas total and static pressure, the compensator is properly adjusted. The index knob is actually the knob of a tap switch that sets the correct value of C in Fig. 2a or of R_p in Fig. 2b.

(2) The time constant is a function of the rate of cooling of the thermocouple. The electrical power required to maintain the thermocouple wire a certain number of degrees above the gas stream temperature is a measure of this cooling and thus can be used to determine the time constant. In this method, shown in Fig. 5a, an a-c heating current is used. The thermocouple emf is measured by a potentiometer after the a-c voltage produced by the heating current is eliminated by the a-c rejection filter. A blocking capacitor prevents loading of the thermocouple by the heating circuit. The value of the time constant is given by the formula:

$$\tau = \frac{\pi^2 \rho_w c_w D^4}{16 \rho_e} \left(\frac{T_w - T_g}{I^2} \right) \qquad (7)$$

where

ρ_e is the electrical resistivity

$T_w - T_g$ is the temperature rise of the wire

I is the heating current.

Since the product $(\pi^2 \rho_w c_w D^4 / 16 \rho_e)$ is independent of gas flow conditions, its value can be computed in advance, so that the time constant is given by:

$$\tau = \text{constant} \times \frac{(T_w - T_g)}{I^2} \qquad (8)$$

The direct calculation of the constant in Equation 8 requires an accurate

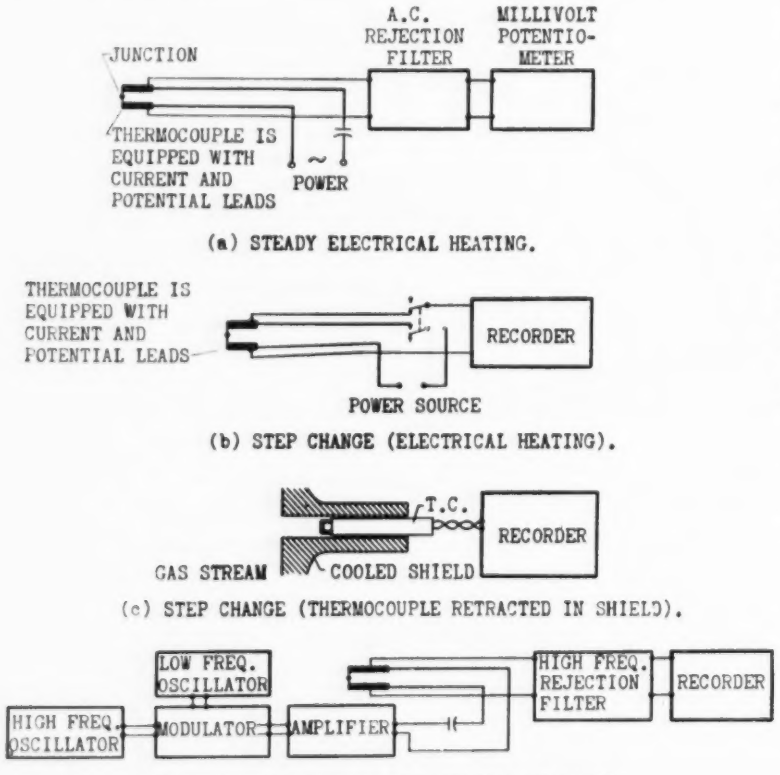


Fig. 5. Methods of determining time constant.

knowledge of the wire properties, especially of the diameter. In an alternate method requiring no knowledge of the wire size and properties, a single experimental determination of τ, T_e-T_g, and I can be made, where τ is determined by some other independent method, and the value of the constant then computed from this single set of measurements.

(3) For a more direct measurement of the time constant, the thermocouple is heated electrically and the exponential decay of the output is recorded after the heating current is disconnected (Fig. 5b). The time constant is found by determining the time required for the change in output to reach 63 per cent of its final value.

(4) Another method in which the time constant is determined by means of the exponential decay curve makes use of a shield into which the thermocouple can be retracted (Fig. 5c). The shield is kept at a different temperature than the gas stream and when the probe is quickly inserted into the gas stream, a step change in temperature occurs. This method is especially useful in applications where the thermocouple must be retracted to protect it from burn-out, so that the shield is already available. A variation of this method makes use of the compensator in the circuit. As the thermocouple is repeatedly inserted into the gas stream, the compensator is adjusted until a step change in output is obtained.

(5) A frequency-response analysis can be made using a high-frequency heating current that is amplitude modulated by a low-frequency signal (Fig. 5d). The cut-off frequency is determined by locating the point at which the amplitude drops off by a factor of $1/\sqrt{2}$.

Complete Compensating Systems

So far only the response characteristics of the thermocouple-compensator combination have been discussed. In any practical situation, a detector or recorder and possibly an amplifier and step-up transformer are added to form a complete compensating system capable of measuring the desired gas temperature.

The compensating system must be designed so that the performance specifications will be met for a particular problem in the measurement of temperature fluctuations. These specifications include:

(1) The frequency range to be covered.

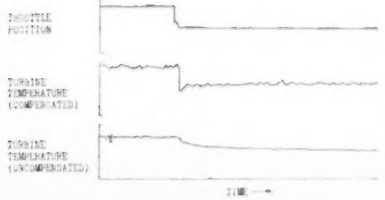


Fig. 7. Engine transient record.

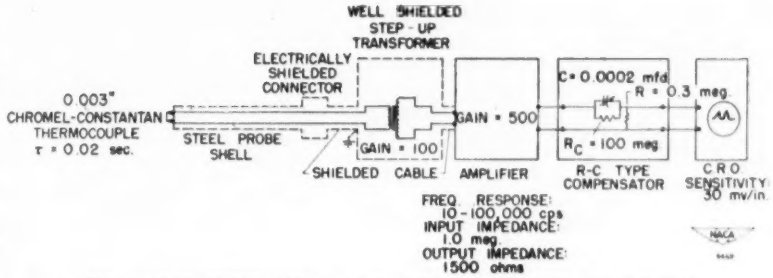


Fig. 8. Compensating system for compressor temperature measurements.

(2) The minimum signal to be measured.

(3) The clarity, or signal-to-noise ratio, with which the minimum signal is to be measured.

As to frequency range, most temperature measuring problems fall into one of two groups: (a) the situation where the d-c and the relatively low-frequency components are to be measured, and (b) the situation where the fairly high-frequency components are of major interest and where the d-c and very low frequency a-c components may be suppressed.

The minimum temperature signal which can be detected may be limited by either insufficient sensitivity of the system, or by extraneous signals (noise or "pickup"). The sensitivity can be raised by using additional stages of amplification. Amplifier noise can be reduced by first choosing an amplifier having a low input noise level, and then limiting the frequency pass band of the amplifier so that a lower output noise is obtained. Pick-up voltages may be reduced by careful shielding.

Temperature variations of much higher frequencies than the phenomenon being studied can also be considered "noise", since they interfere with the desired record. These variations can usually be filtered out by limiting the frequency range of the system effectively to cover only the temperature changes of interest.

Minimum signal-to-noise ratio which can be tolerated is determined by the nature of the application and by the patience of the engineer who must read out the temperature variations. Two typical examples of the measurement of fluctuating temperature in jet engines will be discussed.

System for Turbine Outlet Gas Temperature

In the measurement of the turbine outlet gas temperature of an engine being tested for performance, the d-c and low-frequency components of temperature are of major interest. The thermocouple time constant may be of the order of one second. An improvement of 30 times would provide adequately rapid response for most engine transient measurements, and can be obtained by use of the tranformer-type compensator. If a low resistance thermocouple and a high impedance detector are used, no loss in the signal level occurs and the reduction in effective time constant is approximately N, the turns-ratio.

The recommended circuit for this application is shown in Fig. 6 and consists of a 40-mil butt-welded, bare-wire thermocouple, the transformer-type compensator, and a direct-coupled amplifier-recorder. The sensitivity of this system is determined by the thermoelectric power of the thermocouple and the sensitivity of the amplifier-recorder, since there is essentially no attenuation of the d-c level of the temperature signal. For a system using an amplifier-recorder having a sensitivity of 2.5 millivolts/inch deflection, and using a Chromel-Alumel thermocouple, an over-all sensitivity of 100° F/inch is obtained.

A typical record obtained with this system, showing the effect of a step change in fuel flow to the engine, is shown in Fig. 7. The compensated thermocouple gives a much more accurate picture of the actual engine temperature variations than does the uncompensated thermocouple.

System for Compressor Temperatures

For temperature variations occurring in compressors, the higher frequency components are to be measured. The system makes use of a 3-mil butt-welded, bare-wire thermocouple, the R-C compensator, and a cathode-ray oscilloscope. In the previous discussion on the R-C compensator, it was pointed out that the reduction in effective time constant was obtained only at the expense of a corresponding reduction in signal level. Therefore, additional components must be added to the system to raise the signal level.

The need for a preamplifier is obvious. However, it should be chosen with care, since its noise will tend to mask the signal. Although it is frequently possible to construct the compensating system using commercially available amplifiers, unusually severe requirements, such as very low minimum signal to be measured, may force the development of special amplifiers.

The measure of amplifier noise is the equivalent input noise level, that is, the fictitious rms sinusoidal voltage which, when applied to the amplifier input, would produce an rms output voltage equal to the actual rms output noise voltage. Since the signal voltage of the thermocouple decreases with frequency, the input noise level imposes a limit on the minimum size of the signal which can be success-

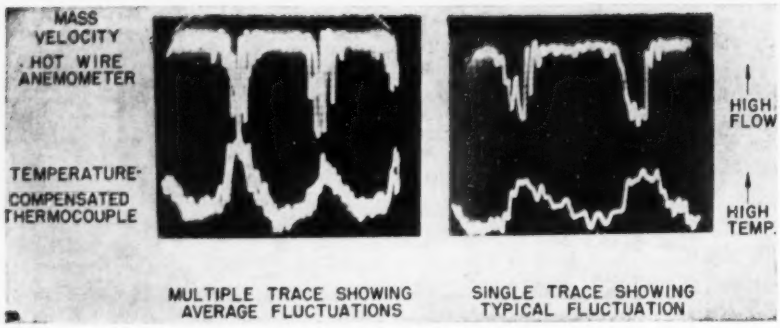


Fig. 9. Compressor rotating stall oscillograms.

fully amplified. However, since the thermocouple has a rather low resistance and the input impedance of the amplifier is generally high, a matching transformer can often be inserted advantageously to raise the signal level by the amount of transformer gain—sometimes as much as 100X—without a corresponding increase in amplifier noise.

This matching transformer must be of well shielded hum-balanced construction, so that it does not add pick-up voltages to the system. If this type of transformer is used, the minimum signal which can be detected is reduced by a factor equal to the transformer voltage gain. It should be noted, however, that although the inclusion of the transformer effectively reduces the effect of amplifier noise, it does not aid in the reduction of stray pickup voltages by the thermocouple and its leads. This pickup must be minimized by very careful shielding of the leads and the grounding of these shields.

The complete system, shown in Fig. 8, now consists of the thermocouple, the step-up transformer, the low noise level amplifier, the R-C compensator, and the cathode-ray oscilloscope. Since a transformer and an a-c amplifier are being used, the system will not pass d-c. The low-frequency cut-off point is usually determined by the transformer and is about 10 cycles per second for the components shown in Fig. 8.

The time constant of the 3-mil thermocouple is about 0.02 second, so that, with a reduction in effective time constant of 300 times, the system has a flat frequency response from 10 to 2400 cycles per second. This system has an over-all sensitivity of approximately 80° F per inch. With an amplifier input noise level of 10 microvolts, a transformer gain of 100X, and under ideal conditions of no stray voltage pickup, temperature variations of 2° F can be measured with a signal-to-noise ratio of 3.

In Fig. 9, oscillographic records of a compressor rotating stall are shown, as taken with the apparatus of Fig. 8. The upper sections of the figure show the mass-flow variations as measured by the constant temperature hot-wire anemometer; the lower sections of the figure show the corresponding temperature variations as measured by the compensated thermocouple system. The abscissa is time, and the fundamental frequency of the variations is about 200 cycles per second.

The peak-to-peak temperature variation is about 70° F and the flow varies from 0 to 100 percent of the unstalled flow. The temperature rises as the flow decreases. The patterns on the left are multiple traces that give the average variation; the patterns on the right are single traces that show typical instantaneous flow and temperature variations.

Other compressor phenomena which can be studied with a compensating system like that shown in Fig. 8 include surge and blade-wake variations, both of which show temperature patterns similar to the mass-flow variations indicated by the hot-wire anemometer. In general, the problem of stray pickup is much more serious with the compensated thermocouple system than with the hot-wire anemometer system, since the thermocouple is working at a much lower voltage level than is the anemometer.

As stated before, the stray pickup can be minimized by the use of well shielded components, especially the transformer, and by intelligent shielding of leads and grounding of these shields. Inductive loops and multiple grounds should be avoided. Better results are often obtained when the thermocouple and its shielding are insulated from the engine or test rig.

A balanced input will minimize electrostatic pickup; shielding in the form of solid-wall steel tubing often reduces magnetic pickup. In spite of these precautions, we find that magnetic pickup often limits our ability to measure temperature fluctuations in blade wakes, since these fluctuations are of smaller magnitude and occur at higher frequencies than in the case of compressor surge and stall.

Conclusions

Compensated thermocouple systems such as those described are finding greater utility in providing information of a fundamental nature concerning flow and combustion phenomena in jet engines. This information supplements that obtained by use of the hot-wire anemometer.

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Calculation of Liquid Flow Coefficients

The most common inferential flow-measurement technique makes use of the sharp-edged orifice. Basic flow equations are derived with the five correction factors required. Two examples illustrate use of the SCMA tables for rapid calculation of the orifice coefficient.

By RICHMOND M. VOILS, JR.
General Petroleum Corp.

COMMERCIAL flow-measuring systems can be divided into open and closed systems. Open-flow systems consist of Pitot tubes, wiers, and flumes. The Pitot tube is a velocity-measuring device and is used extensively in air-speed indication, but has the disadvantage in volume measurement of measuring velocity only at the point of location, making complete traverses necessary for accurate flow measurement. Various forms of wiers are still used widely in open-channel flow, the most widely used being the V notch, the rectangular, and the Cippoletti. The newest development in open-channel flow measurement is the Parshall flume developed by R. L. Parshall in conjunction with the Colorado Agricultural Experimental Station and the United States Division of Irrigation; this flume is a variation of a Venturi section.

The oldest of the closed-channel methods of flow measurement consists of the Venturi tube, which still is used at locations in which a low pressure drop is of great importance, or when there is a large percentage of contaminants. It can also be used successfully on the more viscous fluids. A variation of the Venturi tube is the flow nozzle, which has cheaper initial cost. Pitot tubes are used in certain closed-channel measurement, mostly in duct circuits or in open flow tests of gas wells.

The most common of the present-day commercial methods of inferential measurement in closed-channel circuits uses a thin sharp-edge orifice as the primary element. The thin plate produces a pressure drop which can be measured by a manometer. Most commercial plates are of the concentric type, and it is this type of plate which the following calculations will fit most accurately. However, eccentric or segmental orifices are used where vapor entrainment is a problem (the dam would be in the low position), or in cases of solid contaminants (the dam would be in the upper section of the flow channel).

Manometer Taps

In connecting the manometer across the plate, several standards have been tried. The two which are most common in commercial use are "pipe" taps and "flange" taps. Pipe taps are arranged so that the upstream pressure is taken at a point 2½ nominal pipe diameters from the plate face, and the downstream tap 8 nominal pipe diameters from the downstream face. Flange taps are located 1 inch upstream and 1 inch downstream from the respective faces. Another tapping system is the "vena contracta" at 1 pipe diameter upstream, and at point of minimum pressure downstream. This type of tap is obviously for steady flow rates and is therefore being generally replaced by "radius" taps at 1 diameter upstream and ½ diameter downstream. This system, however, is usually physically restricted to 6-inch and larger pipe. Of the four mentioned tap systems the "flange" system has become the most widely used for two reasons—(1) the meter tube can be shorter, making a more compact unit, and (2) the tube need not be held to as close a tolerance for equal coefficient accuracy.

The meter tubes or runs for liquid measurement are in general kept to the standards as set forth in the American Gas Association Standards or the California Natural Gasoline Association (Bulletin #TS-353). Normally, a tube of 40 pipe diameters upstream length and 5 diameters downstream length is recommended.

Flow Equation Derivation

Flow across any orifice follows the basic equation:

$$Q = CAV \qquad (1)$$

where Q is the volume passed, C is a coefficient of discharge, A is the area of passage, and V is the velocity. The velocity obeys the "freefall" equation:

$$V = (2gh)^{1/2} \qquad (2)$$

where g is the constant of acceleration (32.17 ft./sec./sec.), and h is the energy expended in ft. of flowing liquid.

To correct for the velocity or approach at an infinite Reynolds number, and for a Reynolds number less

December Meeting: Thursday, the 17th, Rio Hondo Country Club, Downey, Calif. *Feature*: Past President's Night.

than infinity, let us make C in the basic equation be:

$$C = K_o \times F_r$$

Converting formula (1) into standard units of feet of water, and dividing h by G_f, the specific gravity of the fluid at flowing conditions, the formula for Q in gallons per hour becomes:

$$Q = (3600)\ (7.481)\ (K_o)\ (F_r)\ (0.7854)\ (d^2/144)\ (2gh/12G_f)^{1/2} = (340.1)\ (K_o)\ (F_r)\ (d^2)\ (h/G_f)^{1/2} \quad (3)$$

where d is orifice diameter in inches. This equation gives gallons per hour at flowing conditions. To correct to standard conditions, or 60 deg. F., let us define a temperature correction factor as:

$$T_c = G_f/G$$

where G is the specific gravity at 60 deg. Multiply equation (3) by T_c, and substitute GT_c for G_f:

$$Q = 340.1\ K_o\ F_r\ d^2\ (hT_c/G)^{1/2} \quad (4)$$

For manometers employing a fluid other than the flowing fluid, a correction must be made for h due to the differences in densities. If the manometer depression is h_1, the actual differential h is:

$$h = h_1G_m - h_1G_s$$

where G_m is the gravity of the manometer fluid and G_s is that of the flowing fluid. Substituting this in equation (4):

$$Q = 340.1\ K_o\ d^2\ F_r\ (T_c/G)^{1/2}\ (h_1)^{1/2}\ (1-G_s/G_m)^{1/2} \quad (5)$$

To simplify this flow equation, the following substitutions are made: (1) For a given plate and line size, the basic uncorrected coefficient $340.1\ K_o\ d^2$ can be called C_L. (2) The gravity correction $(1/G)^{1/2}$ is called L_g. (3) The temperature correction $(T_c)^{1/2}$ is called L_t. (4) The manometer correction factor $(1-G_s/G_m)^{1/2}$ is called F_m.

Equation (5) then becomes

$Q = C_L\ F_r\ L_g\ L_t\ F_m\ (h_1)^{1/2}$, which can be contracted further to

$Q = C'\ (h_1)^{1/2}$ for a direct-reading manometer, in which C' is an individual coefficient for any given case, and h_1 is the manometer reading in inches water.

The square-root type of chart recording is becoming increasingly popular because it extracts the square root automatically. For installations using square-root records, this equation becomes

$$Q = C_s h_s$$

in which C' is modified by a factor M to convert it to square-root chart volumes. The factor $M = 0.1\ (m)^{1/2}$, in which m equals the manometer range and h_s represents the chart integration.

Discharge Coefficient

The original flow equation ($Q = CAV$) contains the basic coefficient of discharge C with corrections for velocity of approach and Reynolds number: $C = K_oF_r$. The coefficient of discharge for all fluid measurement has been set up in empirical equations developed by Dr. Buckingham and Mr. Bean of the National Bureau of Standards as follows:

For pipe taps:

$$K_o = \frac{K_e}{1+\frac{(J+B)15}{10^6}}$$

$$K_e = 0.5993 + \frac{0.007}{D} + \left(0.364 + \frac{0.076}{\sqrt{D}}\right)\beta^4 + 0.4\left(1.6 - \frac{1}{D}\right)^5\left(0.07 + \frac{.05}{D} - \beta\right)^{5/2} - \left(0.009 + \frac{0.034}{D}\right)(0.5-\beta)^{3/2} + \left(\frac{65}{D^2} + 3\right)(\beta - 0.7)^{5/2}$$

$$B = \frac{530}{\sqrt{D}}$$

For flange taps:

$$K_o = \frac{K_e}{1+\frac{(J+B)15}{10^6}}$$

$$K_e = 0.5925 + \frac{0.0182}{D} + (0.44 - \frac{0.06}{D})\beta^2 + \left(0.935 + \frac{0.225}{D}\right)\beta^5 + 1.35\beta^{14} - \frac{1.43}{\sqrt{D}}(0.25-\beta)^{5/2}$$

$$B = \frac{875}{D} + 75$$

where β is d/D, the orifice diameter divided by the inside pipe diameter.

Tables of the SCMA

The flow formula for direct-reading manometers is:

$$Q = C_LF_rL_gL_tF_m(h_1)^{1/2}$$

and that for flow recorded on square-root charts is:

$$Q = C_LF_rL_gL_tF_mMh_s$$

Each factor in these equations can be taken separately and found from the tables of the Southern California Meter Association, as follows:

C_L is tabled for flange and pipe taps on Data Sheets 145 and 146 for given pipe and orifice sizes of recommended β ratios between 0.2 and 0.67.

L_g can be obtained from table 248.

L_t can be obtained from table 150 or 151, in which L_t is the factor for a base of 60 deg. F.

F_m for mercury manometers can be obtained from table 249. When a liquid other than the flowing liquid is used as a seal, the seal pots must have a cross-sectional area large enough that the head displacement does not induce a second displacement factor. For normal flows, 4-inch pots are considered adequate; 6-inch pots are used for large flow variations. For recording instruments other than sealed manometers (such as bellows types) the F_m factor does not apply.

M can be obtained from table 226. For noncompressible fluids, the 100# spring range column is used for all commercial manometer ranges.

F_r is the Reynolds number factor, which accounts for viscosity effects. Research on this subject is not complete, but graphs 175, 175A, and 175B have given satisfactory results. F_r is given by $(1+J\ B)d/R$, where R (Reynolds number) is $52.66QG/dy$, where y is the viscosity of fluid at flowing conditions expressed in centipoises. Ordinarily with light hydrocarbons, gasoline, or light oils it will not be necessary to use this factor. However, when a doubt exists it is always best to calculate to see if it lies within significant values.

To transpose viscosities in seconds for use in the Reynolds-number formula, use the following relationship:

$$y = 100G(AS - B/S)$$

Viscosimeter	A	B
Saybolt Universal	0.0022	1.8
Saybolt Furol	0.0204	1.6
Engler	0.0015	3.74
Redwood	0.0026	1.72
Redwood Admiralty	0.0270	12.00

S representing the viscosity in seconds with the viscometer used.

Illustrative Problem

Given conditions: (1) Viscosity = 4.0 centipoises. (2) Pipe taps. (3) Orifice diameter = 5.000 inches. (4) Direct reading chart. (5) Tube diameter = 8.071 inches. (6) Manometer range = 50-in. water. (7) Specific gravity = 0.75. (8) Water seals. (9) Temperature = 100 deg. F.

$$Q = C_LF_rL_gL_tF_m(h)^{1/2}$$

C_L from table 145 is 7196.
L_g from table 248 is 1.155.
oAPI from table 147 is 57 deg.
L_t from table 150, group III is 0.9878.
Q approx. is 7196 x 1.155 x 0.9878 x $(50)^{1/2}$ = 58000 gal./hr.
R from table 242 is 114,200.
β is 5/8.071 = 0.62.
(J+B)d from graph 175B is 1850.
F_r is 1+1850/114200 = 1.006.
F_m from table 249 is 0.962.
C' is 7196 x 1.155 x 0.9878 x 1.006 x 0.962 = 7945.
$Q = 7945\ (50)^{1/2} = 56{,}179$.

Problem No. 2

Given conditions: (1) Viscosity = 220 saybolt universal. (2) Flange taps. (3) Orifice = 2.500 inches. (4) Square-root chart. (5) Tube = 4.026 inches. (5) Manometer range = 50-in. water. (6) Specific Gravity = 32° API. (7) Diethanolanime seals (1.02). (8) Temperature = 100 deg. F.

$$Q = C_LF_rL_gL_tF_mMhs$$

C_L from table 146 is 1395.
S.G. from table 147 is 0.865.
L_g from table 248 is 1.076.
L_t from table 151, group I is 0.9920.
M from table 226 is 0.7071.
Q approx. is 1395 x 1.076 x 0.992 x 0.7071 x 10 = 10520.
y = 100 x 0.865 (0.0022 x 220 − 1.8/220) = 41.2.
R is 52.66 x 10520 x 0.865/2.5 x 41.2 = 4655.
β is 2.5/4.026 = 0.62.
(J+B)d from graph 175A is 1120.
F_r is 1+1120/4655 = 1.2405.
F_m from table 249 is 0.962.
C' = 1395 x 1.24 x 1.076 x 0.992 x 0.962 x 0.7071 = 1257.

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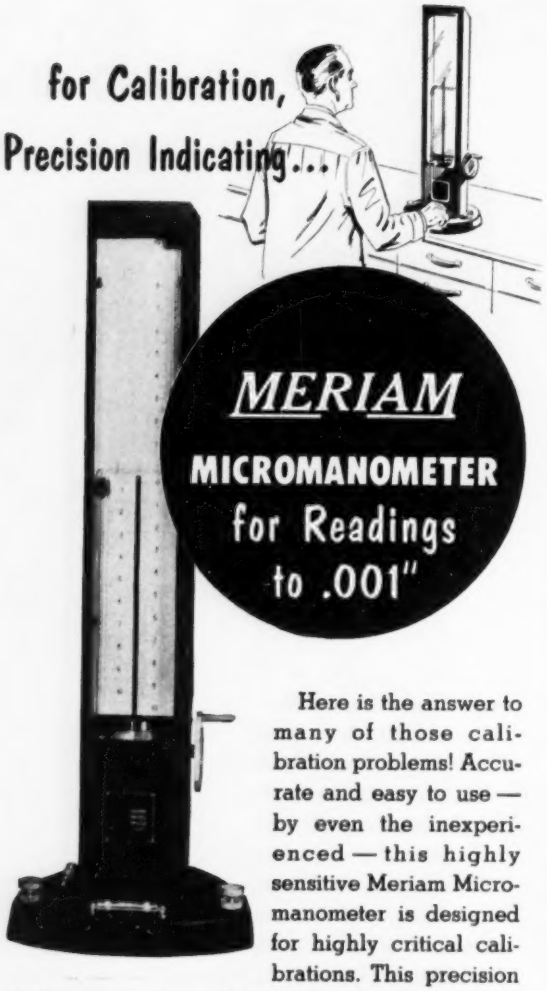

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POTENTIOMETER

Continued from page 1713

the source current (i_s). In standardization of equivalent-noise-resistance measurements, the source current has been arbitrarily set at 1 milliampere flowing from the contact to the winding, and the standard rate of slider rotation has been chosen to be 4 rpm.

The definition of equivalent noise resistance (*ENR*) has had a beneficial effect on both potentiometer development and production. It permits quantitative noise measurements to replace earlier subjective forms of testing. It also allows the systems designer to draw an equivalent noise circuit for calculating the effect of residual potentiometer noise in a given application. In addition, wire-wound precision potentiometers now can be constructed to meet specific ohmic values of equivalent noise resistance.

Noise Measurement Instruments

A number of residual-noise indicating systems have been developed. One is an oscilloscope presentation employing the output voltage (e_{ENR}) for vertical spot deflection and the position of the slider for horizontal deflection. Qualitive observations of noise can be made, but it has been found difficult to evaluate noise amplitudes. Large noise peaks are of extremely short duration and are difficult to measure even with a long-persistance screen.

Observational difficulties of oscilloscopic noise presentation have been overcome in a production test instrument which provides a go, no-go indication of equivalent-noise-resistance peak magnitude. The instrument (**Fig. 4**) is called a "Ponogometer" to signify a "*po*tentiometer-*no*ise *go*, no-go *meter*."

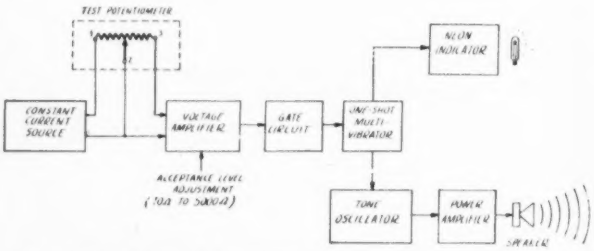

Fig. 4. Block diagram of the "Ponogometer" potentiometer noise tester.

The noise measurement circuit of Fig. 3 is employed at the input to the "Ponogometer." The residual noise output is fed to a voltage amplifier having an input impedance in excess of ten megohms, and a frequency response flat to 50 kilocycles. The amplifier output goes to a gate circuit which provides zero output for input voltages less than 150 volts, and 20 volts output for input voltage peaks in excess of 150.5 volts. The gate circuit triggers a one-shot multivibrator and is used to make system performance essentially independent of multivibrator-tube and circuit characteristics.

When triggered, the multivibrator remains "on" for about a second, lights a neon indicator lamp, and excites a tone oscillator. Thus any peak noise exceeding the defined threshold is indicated both visually and aurally, regardless of how narrow and sharp the peak may be. The "Ponogometer" can monitor equivalent noise resistances ranging from 10 to 5000 ohms to within approximately 3-percent accuracy.

To facilitate potentiometer noise analysis for research rather than production purposes, a Potentiometer Noise Analyzer (see cover) has been developed. A block diagram of this instrument is shown in Fig. 5. A rack-mounted "Ponogometer," permanently set to 10 ohms at 1-ma. slider current, is part of the instrument.

A 5-inch long-persistance oscilloscope provides a visual display of residual noise output as a function of slider position. The "Ponogometer" and the vertical amplifier of the oscilloscope receive their input signals from a cali-

brated attenuator. The vertical-amplifier sensitivity is adjusted so that a 2-inch deflection results from an input voltage just sufficient to trigger the "Ponogometer." A horizontal 2-inch band on the oscilloscope screen thus indicates the threshold of acceptability of ENR signals.

The "Ponogometer" attenuator provides a calibrated 20-db. attenuation dial setting and a decade switch giving attenuations of 1, 10, 100 and 1000. The setting of the attenuator establishes the critical threshold of the "Ponogometer" and the ENR peak magnitude within the band on the oscilloscope face. With a 1-ma. constant-current source and unity gain in the "Ponogometer" amplifier, the "Ponogometer" attenuator has an ENR measurement range from 10 to 100,000 ohms. A noise fluctuation as low as 1 ohm can be discerned easily on the scope face.

For investigation of advanced potentiometer designs and for study of residual noise generated in potentiometer slip-rings, equivalent noise resistances below 10 ohms are important. For this reason a low-noise decade voltage amplifier with high input-impedance was added to the Potentiometer Noise Analyzer. The decade switch provides gains of 1, 10, 100, and 1000. The frequency response of the amplifier is sufficient to provide an over-all system bandwidth which is flat to 50 kilocycles. For a gain of 100 and an excitation current of 1 ma., useful ENR indications of 0.1 ohm are given. Noise estimates as low as 0.01 ohm also can be made.

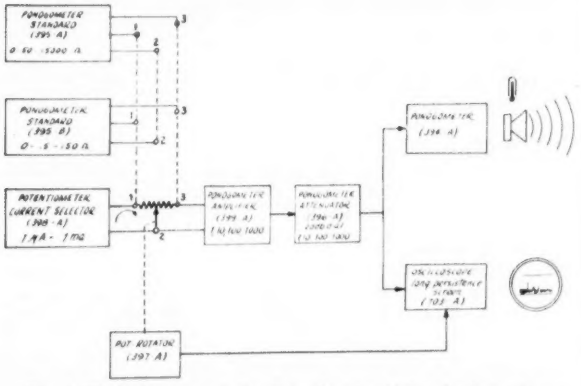

Fig. 5. Block diagram of the Potentiometer Noise Analyzer for research into the magnitudes and causes of residual potentiometer noise.

The Pot-Rotator performs automatic rotation of the slider of the test potentiometer. The body of the potentiometer is gripped in a quick-change chuck and the shaft is coupled by means of a collet to the drive shaft of the Rotator. A horizontal sweep voltage, corresponding to the position of the slider, is furnished to the oscilloscope.

During fully automatic operations the potentiometer is cycled clockwise and counterclockwise at the rate of 4 rpm., reversing itself whenever the limits of potentiometer continuity are reached. At the continuity limits the slider is automatically stopped for about 4 seconds before recycling is begun.

Two "Ponogometer" standards also are provided in the Potentiometer Noise Analyzer. These standard are, in effect, equivalent-noise-resistance generators which can be connected to the input terminals of the system. A calibrated rheostat and an adjustable gap-width rotary switch inject synthetic passive noise pulses of adjustable magnitude and width into the analyzer.

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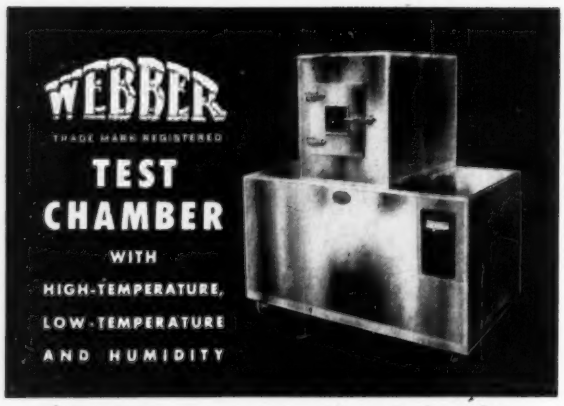

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INSTRUMENT EVENTS Calendar

November 18-20

American Institute of Electrical Engineers Conference on Electronic Instrumentation and Nucleonics in Medicine, New York, N. Y. For information write Raymond C. Mayer Associates, 9 Rockefeller Plaza, New York.

November 19-20

Third Annual Instruments Short Course at Los Angeles Harbor Junior College. For information write Edward A. Reps, Southern Counties Gas Co., Box 2736 Terminal Annex, Los Angeles 54, Calif.

November 30-December 5

24th Biennial Exposition of Chemical Industries at Commercial Museum and Convention Hall, Philadelphia, Pa. For information write 24th Exposition of Chem. Industries, 480 Lexington Ave., New York 17, N. Y.

December 7-10

Midyear meeting of Laboratory Apparatus, Laboratory Equipment, and Optical Sections, SAMA, Boca Raton Club, Boca Raton, Fla.

December 8-10

American Institute of Electrical Engineers Computer Conference, Washington, D. C. For information write Raymond C. Mayer Associates, 9 Rockefeller Plaza, New York.

January 26-27, 1954

American Institute of Electrical Engineers Scintillation Counters Conference, Washington, D. C. For information write R. S. Gardner, A.I.E.E., 29 West 39th St., New York, N. Y.

February 4-6

Sixth Southwestern I.R.E. Conference and Electronics Show held in Tulsa, Okla. Headquarters in Tulsa Hotel. For information contact Dallas R. Davis, P. O. Box 4183, Tulsa, Okla.

March 1-5

Fifth Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy at William Penn Hotel, Pittsburgh, Pa. For information contact R. G. Russell, Gulf Research & Development Co., P. O. Drawer 2038, Pittsburgh 30, Pa.

March 22-25

Institute of Radio Engineers Conference and Exhibit, Kingsbridge Armory, New York, N. Y. For information contact W. Copp, 1475 Broadway, New York 36, N. Y.

April 6-9

Conference on Physics of Particle Size Analysis, sponsored by the Institute of Physics, Nottingham, England. For information write Institute of Physics, 47 Belgrave Square, London, S. W. 1, England.

April 22-23

American Institute of Electrical Engineers Conference on Feedback Control, Claridge Hotel, Atlantic City, N. J. For information write R. S. Gardner, A.I.E.E., 29 West 39th St., New York, N. Y.

April 28-30

Second Annual meeting of ASTM Committee E-14 on Mass Spectrometry, Jung Hotel, New Orleans, Louisiana. For information write J. G. Hutton, General Electric Co., Schenectady, New York.

ROTOMETERS

Continued from page 1716

For gases flowing through a given tube in which a float of relatively high density is used, the term $(\rho_{ft} - \rho)$ becomes approximately equal to ρ_{ft}.

Thus equation 3 for one particular float becomes

$$Q\rho/\mu = B\ [\rho/\mu^2]^m \qquad (6)$$

Flow is generally given as the volumetric flow rate at some standard condition, thus the density term on the left side should be evaluated at the same conditions—that is, the product $Q\rho$ is the mass rate of flow.

The density term on the right side, however, is that corresponding to flow conditions. Consequently, to avoid confusion, subscripts are introduced in equation 6:

$$Q_s\rho_s/\mu_f = B\ [\rho_f/\mu_f]^m \qquad (7)$$

From the calibration data supplied by the manufacturer for dry hydrogen, dry air, and dry CO_2 at two pressures, the term $Q_s\rho_s/\mu_f$ was calculated at various flow rates and plotted against ρ_f/μ_f^2, as shown in Fig. 1.

Except for the lower end of the 50-mm. line, straight lines are obtained at each elevation. The lines are parallel and have a slope of 0.5. Virtual freedom from drag-coefficient variation is thus shown for this instrument over the range of flow indicated. In this case, therefore, equation 7 simplifies to:

$$Q_s = B\ (\rho_f)^{1/2}/\rho_s \qquad (8)$$

or, in terms of volumetric flow rate at flowing conditions:

$$Q_s = B\ (1/\rho_f)^{1/2} \qquad (9)$$

The coefficient B is a function of the float elevation and is numerically equal to $Q_s\rho_s/\mu_f$ where $\rho_f/\mu_f^2 = 1.0$ on Fig. 1.

A plot of B values is shown in Fig. 2. Note that the curve is essentially two straight lines:

For the range 50-350 mm.: $B = 0.0226\ R + 1.39$
For the range 350-600 mm.: $B = 0.0278\ R - 0.37$

where R is the float elevation reading in millimeters. The important observations are the conformity with predicted performance and the tremendous range through which the drag coefficient remains constant. Where this can be assured, one may apply the simplified relation, shown as equation 9, where gases are to be metered, and the coefficient B evaluated from a single set of calibration data.

NOMENCLATURE

B, B'	=	coefficients
D	=	characteristic diameter of rotameter float, feet.
g	=	acceleration of gravity, ft./sec.^{2}
m	=	exponent
Q_s	=	volumetric flow rate at standard conditions, cu.ft./hour
Q_f	=	volumetric flow rate at flowing conditions, cu.ft./hour
v_{ft}	=	volume of float, cu.ft.
W	=	weight rate of flow, lb./hr.
ρ_s	=	density of gas at standard conditions, lb./cu.ft.
ρ_f	=	density of gas at flowing conditions, lb./cu.ft.
μ_s	=	viscosity of gas at standard conditions, lb./ft.-hr.
μ_f	=	viscosity of gas at flowing conditions, lb./ft.-hr.

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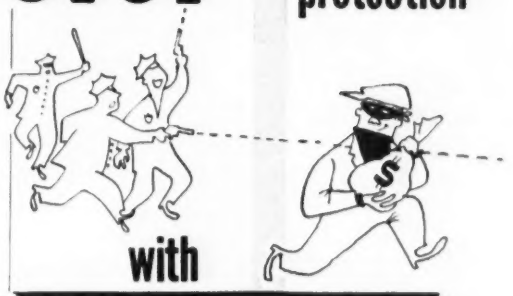

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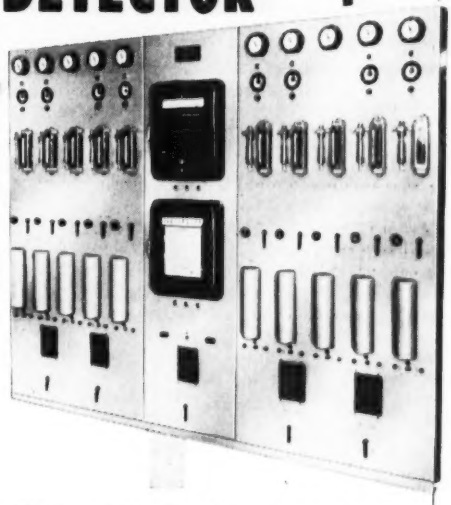

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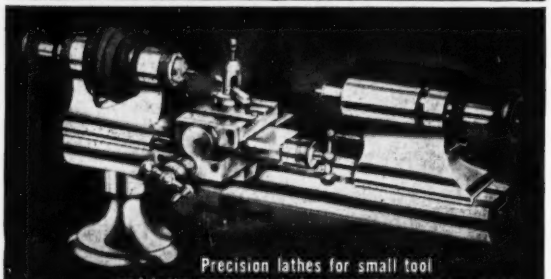

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GUN-BARREL

Continued from page 1715

A study is being made at the Purdue University to determine whether or not the actual response of a thermocouple located in a gun barrel can be fed directly into the thermal analyzer. If this is possible, then many of the assumptions as to time of heat input, etc. may be eliminated as a more accurate boundary condition will be available.

Conclusions

The apparatus and techniques developed can be useful in other fields of research where data on rapid temperature changes are required in the solution of an engineering system. A knowledge of piston and cylinder-wall temperatures would be useful in the study of lubrication and performance of fuels in internal combustion engine research. The apparatus could be used for obtaining time-temperature relations in rapid-quenching operations in heat-treating studies. The work reported should be of value in the study of transient temperature changes in the walls and related parts of combustion chambers of rocket motors. If thermocouples are to be used to measure rapid temperature changes in metallic bodies, the apparatus herein described may be employed to solve the temperature indicating and recording problems.

Acknowledgement

The authors express appreciation to the staffs at the Office of the Chief of Ordnance (Small Arms Development Division), Washington, D. C. and at Springfield Armory, Springfield, Massachusetts, for encouragement and suggestions during the course of this investigation.

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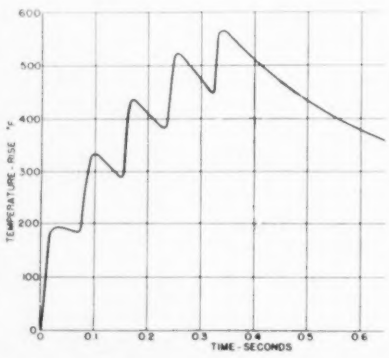


Fig. 6. Temperature-time curve for five-round burst with in-the-wall thermocouple located 0.032 inch from bore surface.

DIGITAL COMPUTERS

(continued from page 1711)

in a predetermined order, but provisions are made also for conditioning the choice of a next instruction upon the results of some operation. Such conditional transfers permit great generality in programming and the solving of problems inherently capable of numerical solution.

MEMORY

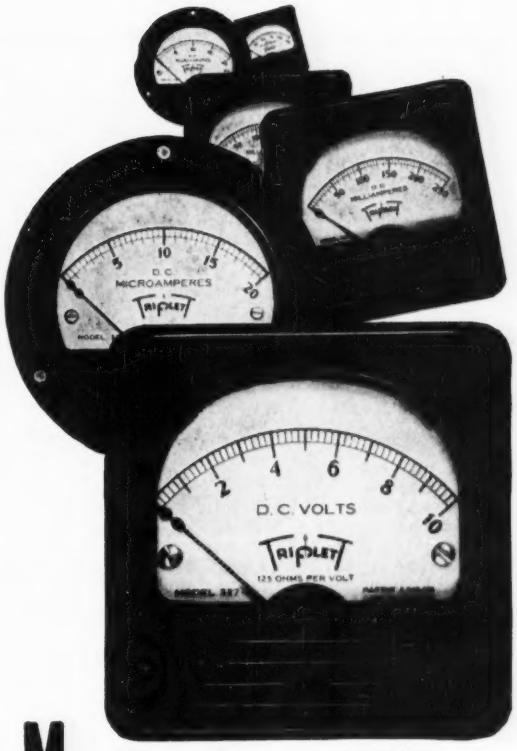
The memory is the essential device. The usefulness of a computing machine depends on the storage capacity of its memory, as this limits the size of the program and the number of possible intermediary results. Access to the desired address of the storage should take a time shorter than that taken by the most frequent arithmetical operation in order to avoid wasting most of the time in mere "flings" and "look-ups."

The requirements of *large capacity* and *short access time* are mutually contrary in storage devices in which all bits of information are in time series. Most present-day memories suffer from this dilemma, so that it is appropriate to classify these devices in order of decreasing capacity and consequent decreasing access time, as follows: (1) Conventional printed matter. The Sunday New York Times has a large information-storage capacity, about one hundred million "bits," but slow input access (printing) and slow output access (human reading). (2) Stack of punched cards. Mechanical preparation, manipulation, and read-out speed up the access time. (3) Teletypewriter perforated paper type. Continuous motion helps in some cases. (4) Modern magnetic tapes. These can be accelerated, moved and stopped rapidly, and can contain desnsely packed information. The over-all figure of merit of combined speed and accessibility is good. (5) The rotating magnetic drum. In this device the access time is determined by the period of rotation, and the storage capacity by the size of its useful storing surface. (6) Delay-line storage devices. Mercury or solid lines utilize acoustical waves to obtain the delay. The signals at the end of the delay line are fed back into the input, after proper amplication and reshaping, and storage is obtained by dynamic regenerative circulation of a train of pulses. Here the conflict between storage capacity (proportional to the length of the line) and the access time (inversely proportional to that length) is evident.

A most desirable storage device is one in which access to any bit of information is direct, without scanning through many bits. Such a "random access" memory is free from the limitation imposed by the use of time as address selecting variable. *Electrostatic storage tubes* were developed to meet this desire. The bits of information are stored in terms of electrostatic charges arranged in a plane array of storing elements. These elements are either small areas, subdivision of a continuous insulating surface, or discrete metallic elements. Access is by directing a stream of electrons to the selected element, which charges to the desired polarity (writing) and produces a signal detecting its polarity (reading). For example, in the Williams system the beam of an ordinary cathode-ray tube is deflected to the selected storing element. The element is charged to one or the other of two polarities, which may be subsequently detected by a mechanism involving secondary electron emission and small beam deflection near the storing element.

In the selective electrostatic storage tube, selection of the storing element is by means of a fixed matrix formed by two orthogonal sets of parallel wires. Electrons bombard the matrix uniformly and are stopped in all windows except a particular one chosen by applying address-selecting voltages to certain groups of wires. Behind the windows are discrete storage elements. This tube, which is intrinsically digital, and the beam deflected tubes with proper artifices, are truly high-speed random-access memories. Unfortunately the storage capacity is limited to the order of a thousand bits per tube, and the costs are high.

There are developments at present which may result in



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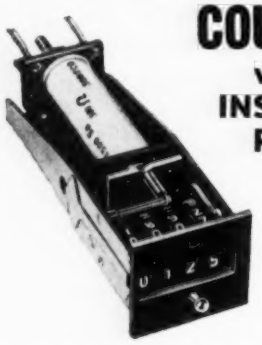

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By judicious combination of large-capacity slow memories with smaller faster ones, computing machines have been built to solve scientific problems. About a score or two are operative.

Input and Output Devices

Many improvements in the input and output devices were made concurrently with the memory development. In the computing part of the machines vacuum tubes are no longer the exclusive switching elements. *Germanium diodes* are now widely used as logical switching elements. This is an example of a solid-state device replacing large numbers of vacuum tubes. The example is to be followed, of course, by use of transistors. It is likely that the computers in the near future will use predominantly solid-state devices—cyrstal diodes, transistors, magnetic cores, and possibly devices based on ferroelectricity or other phenomena in solids.

It is probable that one of the next important phases of the application of digital techniques will be in process control. Improvements in reliability will be required. In addition, important developments will be necessary in instrumentation—as inputs to the computer measuring the state of the process, and in servomechanisms as outputs controlling the process.

A typical example of process control is the final production of nylon. The various qualities desired in the final product (elasticity, wearability, washability, etc.) are complex functions of the production parameters (composition of initial ingredients, temperatures, pressures, etc.) As mass production is a continuous process, the relating of the desired output parameters to the production parameters also must be continuous. This fairly complex computation is a feedback loop now performed by human operators. An automatic computer could be introduced as a part of the loop.

ELECTROMETER TUBES

Continued from page 1709

is reduced greatly, but the time required for a steady or true reading is comparable to the same circuit without feed-back. Such a setting is sometimes desired for scanning work. When the gain of the feedback circuit is set for critical damping, the time constant will be approximately one-tenth the normal *RC*.

The mass-spectrometer circuit shown in Fig. 4 was developed by Stokes at NRL and later at Victoreen. It em-

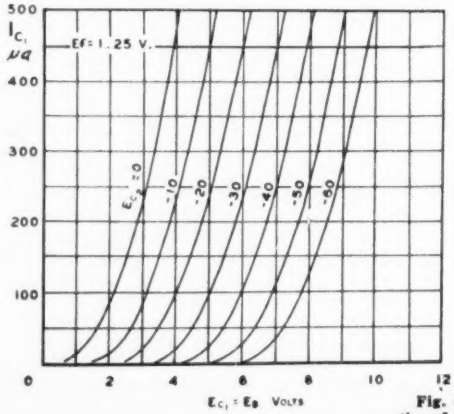

Fig. 5. Characteristics of Type 5800 triode as inverted triode.

ploys negative feedback for stability. Variations on this circuit have proven stable in quality-control testing applications.

Inverted Triode Electrometer

The plate characteristics of the Type 5800 as an inverted triode are shown in Fig. 5.

It frequently is desirable to operate over a wide range of signal voltages. For this application, Victoreen has developed the circuit shown in Fig. 6. Note that the output meter is connected to the first grid, and the second grid is used as the control element. The plate then serves as an electrostatic shield, having virtually no effect on the operation of other elements. Therefore, this is referred to as the inverted triode connection. The voltage gain is the reciprocal of the normal mu of G_2, in this case 1/10. Grid currents in this circuit are frequently less than 10^{-16} amp., making possible open-grid-circuit operation. Note that the charging pulse is applied to G_2 through the chamber capacity. In this manner, the G_2 is used momentarily as a rectifier for charging the chamber. (G_2 is the second, or control, grid.)

Electrometer Triode

Although the tetrode has the smallest grid current, there are other applications requiring higher transconductance, or G_m, even at the expense of grid current. This has resulted in the development of the "electrometer" triode. For some applications requiring higher output currents from the electrometer tube, the triode is preferred.

Fig. 7 and 8 show grid and plate characteristics for a Type 5803 triode. A load line can be drawn on the plate characteristic with the load selected so as to obtain maximum signal range for a relatively constant grid current. A voltage gain of 2 and a transconductance of 150 microm-

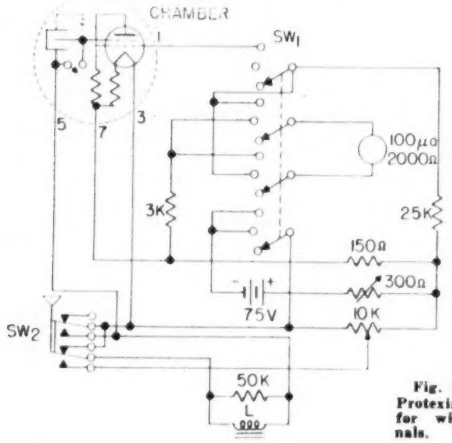

Fig. 6. "Model 300 Protexímeter" circuit for wide-range signals.

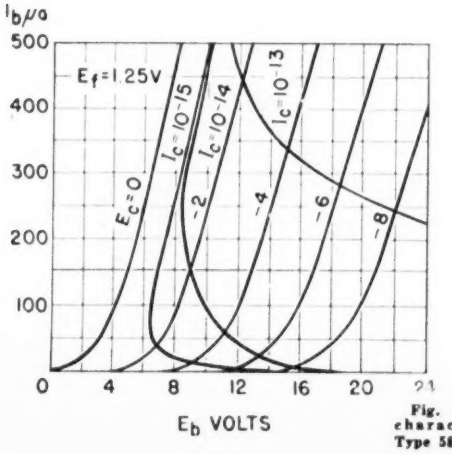

Fig. 7. Grid-plate characteristics of Type 5803 triode.

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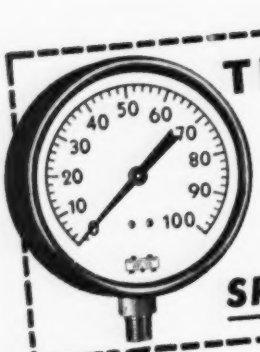

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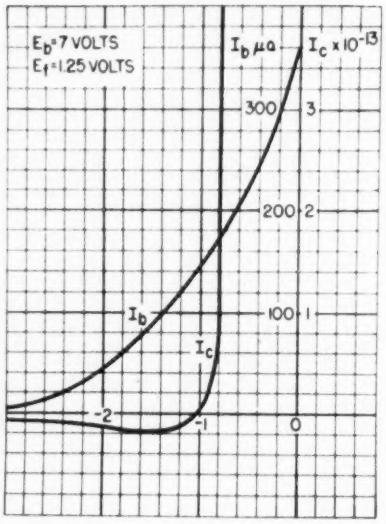

Fig. 8. Grid and plate currents of Type 5803 triode.

hos are readily obtainable from this tube. Typical one-tube circuit applications are found in variations of the "Cutie Pie", a radiation instrument originally developed at Oak Ridge.

A slightly different approach to this type of circuit, shown in Fig. 9, was developed recently by Berg and Charpentier at Victoreen. Intended for semi-quantitative measurements of the type required for civilian defense, this circuit offers a relatively high degree of stability and reliability not usually found in single-tube circuits. The inverse feedback minimizes the circuit drift.

Fig. 10 is the familiar "Zeuto" balanced-pair circuit, worked out by Shonka and others at Chicago. It uses a second tube as a plate load to balance out the effect of battery aging. This balanced circuit will increase the probable error due to change in emission properties of the tube and, therefore, should be used only with tubes having stable emission properties or with tubes known to have emission drift always in the same direction.

An electrometer triode may be used in an inverted connection. In the case of the Type 5803 a mu of ½ and a G_m of 20 may be expected. These triodes are occasionally used in electrostatic voltmeters.

Electrometer Diode

In some circuits, the tubes are referred to as electrometer diodes because their response depends on the diode emission characteristic of the filament to the grid.

The grid current is positive in the region of low grid bias, and the grid current changes exponentially with change in grid voltage. When precautions have been taken to minimize surface leakages, contact potentials, and other extraneous sources of grid current variations, the curve follows the familiar diode-emission characteristics. If we permit the grid to "float" with minimum capacitance, it will seek a potential such that $I_g = 0$.

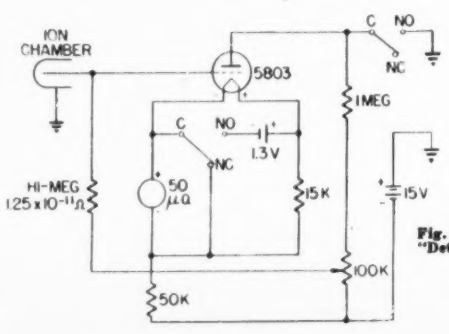

Fig. 9. Single-tube "Detect-r-meter."

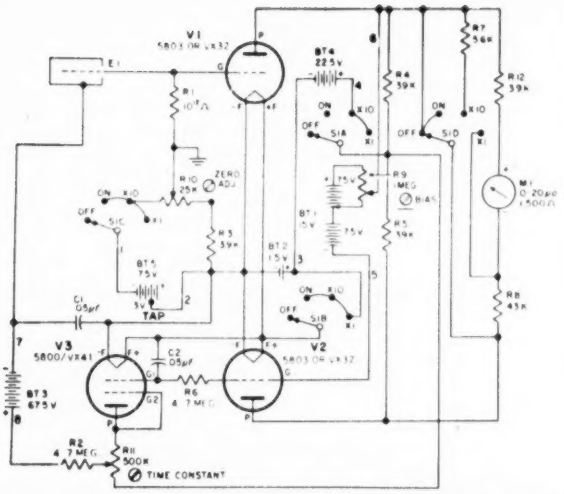

Fig. 10. "Zeuto" balanced-pair amplifier used in "Model 356 Alpha Meter."

Fig. 11 shows an ionization chamber connected to the tube. The positive ion collection current will flow to the grid. The grid will seek a new potential such that the grid current is equal and opposite to the ionization current. Neglecting the effect of leakage currents and gas ion current in the tube itself, the bias voltage for electron-limited grid current is:

$$V = kT/C \ln (I/I_0)$$

When k = Boltzman's constant, C = charge of the electron, T = absolute temperature, I = current, I_0 = current for $V = O$, the bias voltage is determined by the Maxwellian distribution of thermal electron velocities. The resulting plate current change is therefore proportional to the logarithm of the ionization current over several decades. It is limited by nonlinearity in the grid-plate transfer characteristic (on the high-current end,) and by other sources of grid current (on the low-current end).

The time-constant of response to a change in radiation level is a function of the chamber capacitance and the reciprocal of the the grid current. For this reason we find a long time-constant for low intensities and an increasingly shorter time-constant as the level of intensity increases. This feature is desirable for most applications.

Fig. 12 shows a diode detection system used in photocell applications, combined with a bucking chamber. This circuit operates on the same diode characteristic. Its sensitivity is a fraction of a volt per decade of radiation intensity.

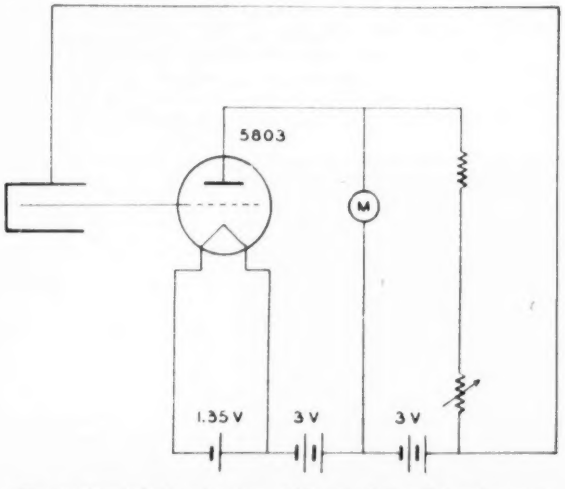

Fig. 11. Logarithmic ratemeter, which uses diode-emission characteristic of the electrometer tube.

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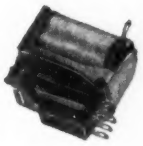

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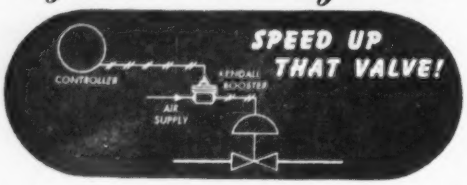

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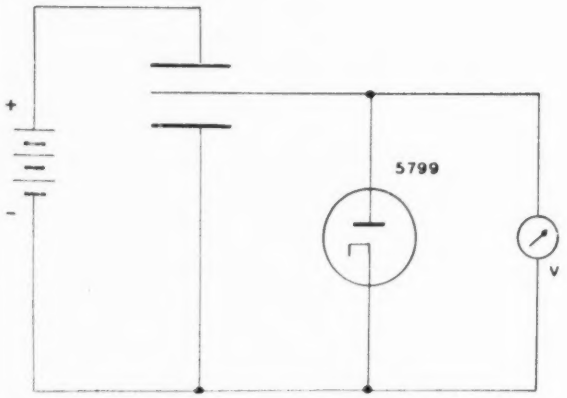

Fig. 12. Logarithmic diode detector.

A high-impedance voltmeter is required in the output. Use of a null-operated feedback circuit to bias the Type 5799 is recommended.

High-Mu Electrometer

Schede at Oak Ridge has made progress with high-gain amplifiers having high percentage feedback to the electrometer tube. He uses G_1 for the control grid and depends on the feedback to hold the grid voltage change to a minimum.

By operating in a region where the grid current is constant, the grid current merely contributes to the grid bias. Special tubes are being developed for this application. If successful, they may offer improvements in stability or sensitivity. The large number of batteries required is a serious limitation to this circuit. The coupling batteries could be replaced by an inverted Type-5803 tube. However, separate filament batteries still will be required.

RHEOLOGY

Continued from page 1523

For typical Newtonian materials (curve 1) the viscosity is independent of the frequency of alternation. However, the response of a typical polymer decreases rapidly with increase in frequency—that is, the resistance to flow decreases as the frequency increases. Rigidity (which is always zero for a Newtonian material) would increase from zero to large values for a polymeric material, as shown by the dotted curve.

The reason for this is that in a continuous-flow-type viscometer, a polymer experiences breakage of linkages, bonds, etc. as the flow produces physical changes in the material. Hence the resistance to flow is relatively large. On the other hand, at high alternating frequencies (and particularly at low amplitudes of stress), no bonds are broken and no cross linkages are disturbed; the molecules are simply caused to oscillate about their central positions

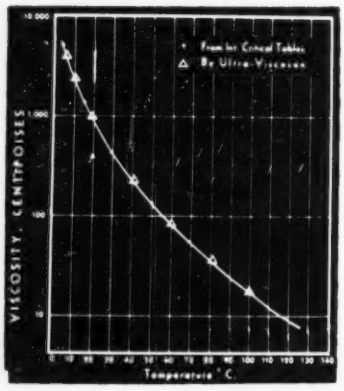

Fig. 4. Viscosity curve vs. temperature for a Newtonian liquid (castor oil).

with small amplitudes, which often are less than the amplitudes of Brownian motion normally present. Thus a much smaller resistance to flow should be expected and this is found experimentally. The use of the principle of measuring viscosity (or resistance to flow) under conditions of alternating stress is advantageous for two reasons—first, it permits characterization of various materials by use of a large number of measuring parameters (and thus enables us to specify more closely the particular material) and, second, it leads to simpler instrumentation for continuous, automatic measurement of viscosity.

"Ultra-Viscoson"

The "Ultra-Viscoson" (Fig. 1) is an electronic instrument which uses ultrasonic waves to measure the viscosity of Newtonian liquids and the apparent viscosity of non-Newtonian liquids, continuously and automatically. It comprises an ultrasonic probe and an electronic automatic computer. The sensing element of the probe is a thin blade of steel alloy which protrudes from a stainless-steel barrel. Ultrasonic waves are produced by the probe in the liquid in which it is immersed. The electronic computer, attached to the probe by a cable, calculates the viscosity of the liquid from the effect of interaction of the ultrasonic waves with the molecules of the liquid. If sufficient liquid surrounds the probe, minute layers are caused to slip back and forth over one another at an ultrasonic frequency. The computer computes the energy required to produce this sliding motion. This energy is proportional to the viscosity of the liquid.

The operating frequency of the standard "Ultra-Viscoson" is 28 kilocycles per second. The peak amplitude of vibration of the probe is less than one micron; the ultrasonic energy in the liquid is in the order of microwatts. This level is far below cavitation levels so as to eliminate any effects that the ultrasonic energy will have on the characteristics of the test sample.

The instrument measures the absolute viscosity of Newtonian liquids from 0 to 50 centipoise x gm./cc. in 4 ranges: 0-50, 0-500, 0-5000, and 0-50,000. Reproducibility is ± 2 percent for liquids having reproducible rheological properties, whether Newtonian or non-Newtonian. The absolute accuracy for Newtonian liquids in the 0-1000 centipoise gm./cc. range is better than ± 2 percent.

Features of the instrument include: (1) Hermetically-sealed all-metal probe. (2) Can be used from 0-1000 psi. and higher on special units. (3) Rated for continuous service up to 650 deg. F. (4) Readings are independent of flow velocity unless the characteristic of the material is a function of flow. (5) Response time is less than 1 second. (6) A mile of separation is permitted between probe and computer. (7) Automatic temperature-compensation equipment is available. (8) Multipoint systems are available in which many probes can be operated from computer.

COMPRESSED AIR

Continued from page 1705

surface, then, it appears that the compression has reduced the relative humidity. This is true only for an adiabatic compression—that is, a compression whereby all the generated heat is retained. However, compressed air is not usually used at the temperature created during compression. Much of the heat is dissipated by radiation through the walls of the cylinder. More is lost as the air progresses through the air lines to the receiver, and the receiver itself dissipates more of the developed heat.

If an aftercooler is used, still greater temperature reduction is accomplished and the air is usually about 15 or 20 degrees higher than ambient temperature at its point of use. On the basis of this reduction in temperature, the compression can be considered to be more isothermal* than adiabatic.

Continued on next page.

*Isothermal compression is one in which the temperature is maintained constant.

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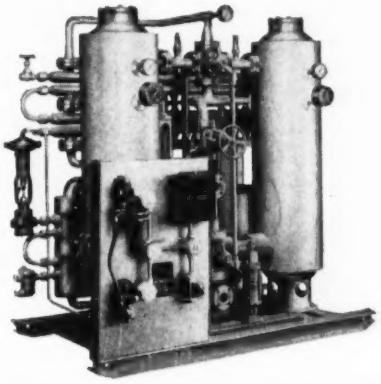

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In isothermal compression we can disregard the effect of temperature. At the higher pressure, the water vapor that is compressed with the air usually will exceed the maximum amount of vapor the air can hold, and the excess vapor condenses as liquid. The liquid that condenses flows with the saturated air through the lines, and can be trapped out at a convenient low spot. However, this elimination of the liquid water is far from a complete solution. As the saturated air continues through the lines it continues to lose heat, and every slight reduction in temperature causes additional condensation until the compressed air reaches ambient temperature. In order to prevent this condensation at various points, the moisture must be *removed* from the air so that the relative humidity is low at ambient temperature—that is, the dew point of the air must be lowered so that it is below ambient temperature.

In compressed air the second most serious contaminant is oil. Heat developed during the compression cycle vaporizes the oil that lubricates the compressor; this vaporized oil is carried along with the water vapors in the air. Oil vapors condense as do water vapors, and the condensed oil adheres to the inside of the air lines and creeps along as the air flows to its point of use. Like water vapor, oil as a pure vapor cannot be removed by ordinary mechanical filters, and must be condensed into a liquid to be removed from the system. Even worse than clean condensed oil is oil that has been carbonized by friction and heat developed during compression. The problem of oil in all its forms can be eliminated by use of carbon-ring compressors. However, if the carbon ring wears, carbon dust can become the contaminant.

Rust and scale, especially in iron-pipe systems, also must be removed. The worst possible combination of contamination in air lines is an emulsion of condensed oil and water, mixing with tar and carbon products from the compressor, together with bits of scale and rust normally found in a corroded air line. This combination forms a sludge that gums up valves and orifices, and has on occasion completely shut down large industrial installations controlled by compressed air.

Filtering and Dehydrating Devices

There are many devices designed to clean and dry air and gases. As with other devices, each type has advantages and limitations. The three basic types are (a) mechanical, (b) cooler type, and (c) desiccant type.

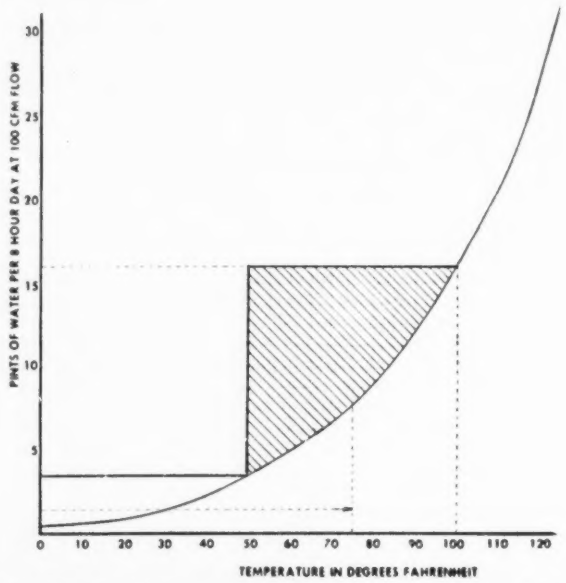

Fig. 2. Saturation curve, showing pints of water carried in 8 hours by saturated air flowing at 100 CFM.

The mechanical is the least expensive; the desiccant the most expensive; the choice depends on the results desired.

Traps.

The most common mechanical-type device is the trap. Traps, if properly serviced, are effective in removing solid and liquid contaminants. However, the air downstream of the trap remains saturated with water and oil vapors. The traps must be located close to the point of use of the air to be effective, and even then any temperature reduction beyond the trap causes additional condensation.

Separators

Another mechanical device for the removal of liquid contamination is the separator. The two most common types are those that operate by centrifugal action, and those that use the expansion principle for cooling the air. In the former, or "cyclone" type, the air is admitted from the air line into a chamber, often in a tangential manner. The centrifugal velocity of the air as it whirls through the chamber dispels the moisture by throwing it against the sides of the chamber. If the air is moving through the lines at a high velocity, this type of separator is of benefit. However, when air is compressed, its volume is reduced and the air moves through the lines at a low rate of speed. As the air passes from the line into the centrifugal chamber, the larger volume of the chamber slows down the air and its centrifugal velocity may be low. A centrifugal-type separator is most effective when the outlet from the separator is at a low pressure so that the air velocity is high.

The *expansion-type separator* uses expansion of the air to reduce the temperature and thus cause condensation of liquid. This expansion is not effective when the downstream pressure is near the pressure in the separator because a back pressure against the expansion orifice retards the expansion. The designers of this type of equipment are right in the theory that the temperature of the air should

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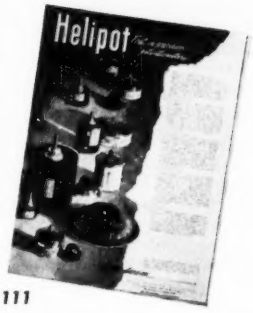

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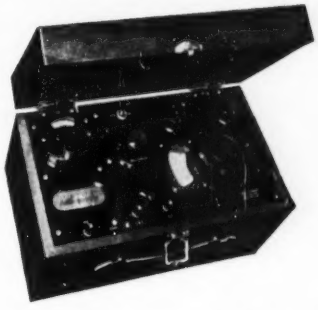

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be reduced. However, the temperature reduction is limited by the fact that no cooling medium is used.

There is one serious drawback in all separators that depend on mechanical action. As pressure in the system increases, the efficiency of these units decreases because of the decrease in volume and the consequent decrease in velocity.

In mechanical-type filters the temperature of the air is seldom reduced far below ambient temperature. Hence the air leaves the device saturated with vapor at a fairly high temperature. If the outgoing air is used before any further temperature drops occur, the devices function satisfactorily; but if further temperature drop occurs before the air is used, more moisture is condensed in the lines.

Cooling-type Devices

One way to prevent moisture condensation is to cool the air by a cooling device so that the dew point of the air is below any temperature it will encounter before use.

When planning a compressed-air dehydrating and filtering system, one of the first things to consider is the dew point necessary to prevent water from condensing in the lines. If the air lines are indoors, and the ambient temperature is always near 75 deg. F., it is necessary to have a dew point of only 15 to 20 degrees below room temperature—that is, a dew point of about 60 degrees is satisfactory.

An ordinary aftercooler alone can not usually produce even this relatively high dew point because the inlet air temperature to the aftercooler is high, and it is asking too much of one aftercooler to reduce the high air temperature to a below-ambient temperature. However, a secondary cooler downstream of the receiver (following the aftercooler) can take advantage of the lowered temperature and can reduce the air temperature far below ambient, producing a dew point of a few degrees above the cooling-water temperature.

The efficiency of a cooler depends on its heat-transfer properties and on the temperature of the cooling water. If the outlet air temperature from the condenser is two or three degrees higher than the cooling water, the device will be satisfactory if the cooling-water temperature is approximately 20 degrees less than room temperature. When the air has passed through the cooler, and has been reduced to about 20 degrees below room temperature, it is saturated at that temperature. However, when it warms to room temperature again, a spread between temperature and dew point is effected; this spread of about 15 or 20 degrees is sufficient in most cases to prevent further condensation as the air progresses through the air lines to its point of use. Cooling should be done at the highest pressure possible because cooling can be done more efficiently at the higher pressure. Also, by reducing the pressure the dew point and relative humidity are lowered still further.

The advantage of cooling-type devices over mechanical-type devices is that the former provides air with a lower dew point. This advantage is obtained at the cost of added complexity and necessity for use of a cooling medium.

Desiccant Dehydrators

Although desiccant-type dehydrators are more expensive than mechanical or cooling types, there are times when a desiccant dehydrator should be used. If cooling water is unavailable, or if the air lines are subjected to sub-freezing temperature, the air should be put through a desiccant-type dehydrator. The desiccant dehydrator is a device filled with a chemical of hygroscopic qualities. This chemical is porous and absorbs water on its surfaces until it becomes saturated. The desiccant removes the water vapors as the air passes through the desiccant bed, and holds these vapors until the desiccant is heated to a point high enough to boil the vapor off.

A desiccant dehydrator usually consists of two towers. The air passes, on alternate 6- or 8-hour cycles, through one tower and then the other. When one tower is being used to dehydrate, the other tower is heated, either electrically or by steam or gas, to a temperature great enough to cause the desiccant to be reactivated. The moisture boiled out of the desiccant is exhausted to the atmosphere, and

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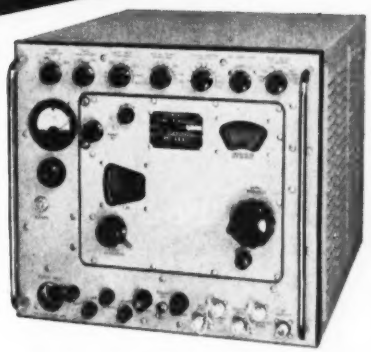

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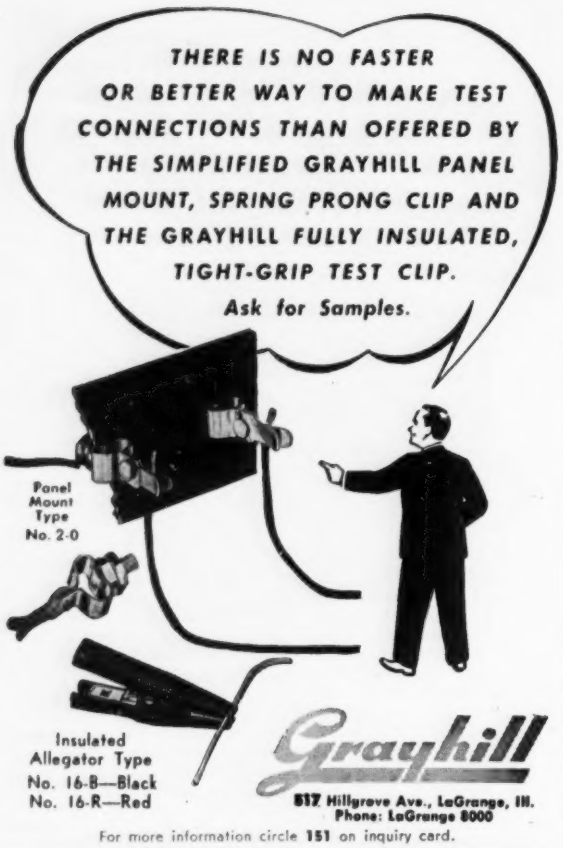

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the cycling is arranged between the two towers so that the air is continually passing through a tower containing reactivated desiccant. The desiccant dehydrator often is used in applications where air lines run out of doors in subfreezing temperatures. With a desiccant dehydrator it is possible to reduce the dew point of the air to below minus 90 deg. F.

It can be advantageous to use a combination cooler and desiccant dehydrator. The saturation curve (Fig. 2.) is parabolic, starting with a flat curve between 0 and 32 deg. F., and increasing in slope steeply through the higher temperatures. Saturated air at 100 deg. F. contains approximately 16 pints of water at 100 cfm. flow per 8-hour day. By cooling this air to 50 deg. F., 12¼ pints of water are removed, leaving only about 3½ pints. By reducing the temperature to 50 deg. F. by a cooling-type dehydrator over ¾ of the water is removed and only ¼ is left for the desiccant dehydrator.

As the desiccant-type dehydrator produces a dew point lower than either mechanical types or cooler types, it is the most effective dehydrator. However, it is also the most expensive.

An efficient cooler removes the major portion of moisture by condensation, and also condenses out most of the oil. With a cooler ahead of a desiccant dehydrator it is possible to reduce the size of the dehydrator and prolong the life of the desiccant by removing the oily contamination.

From the theory, it is possible to select an optimum type of filtering system for each application. For applications where saturated air is satisfactory—that is, where a dew point at ambient temperature is satisfactory, an inexpensive mechanical filter and separator can be used.

Where the dew point should be 15 to 20 degrees below ambient (so that no condensation on delicate parts can occur), and where the air is used in a building at normal room temperature, the best system is a cooler and mechanical filter, together with a trap. The cooler reduces the dew point and removes oil; the mechanical filter takes out the solid particles and any airborne oil mist not removed in the condenser. For outdoor use, this system plus a desiccant dehydrator is the most efficient. The condensing-type filter not only removes the water but also removes the oil that would contaminate the desiccant dehydrator. With this unit ahead of the dehydrator, a smaller dehydrator can be employed. The lower cost of the smaller dehydrator, made possible by the cooler, may more than pay for the cooler itself.

Compressed air can be a constant source of trouble, or it can be dependable and efficient. The cleaning equipment must have periodic service, but this is preferable to running the risk of major repairs to valuable equipment. The cost of "getting by" with dirty air is much greater than the expense of proper equipment to insure trouble-free operation.

NUCLEAR REACTORS

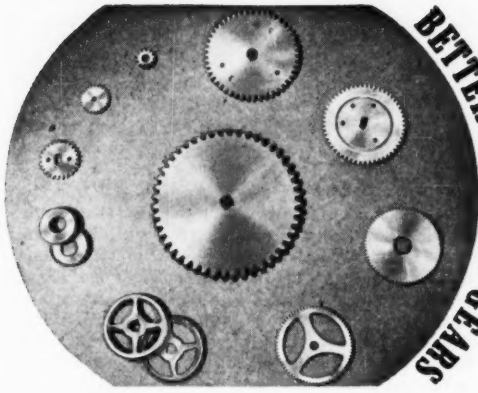
Continued from page 1704

with a potential between 20 and 200 volts. Exposure to radiation reduces this charge, and the amount of reduction is correlated to the roentgen field of radiation.

The discharging capacitor can be read with a built-in electrometer (Fig. 3-3), or the ionization chamber may have connected to it, as an aid in reading the radiation intensity, an electrometer-type direct-coupled amplifier (Fig. 3-4). The disadvantages of an ion chamber are associated with the difficulties in maintaining the extremely high resistance (10^{12} ohms) of the input components associated with the amplifier.

Proportional Counters

A proportional counter, like an ion chamber, is a system of electrodes in a gas which is ionized by the radiation. However, the voltage between the electrodes is adjusted so that the output pulse is proportional to the number of ions produced in the gas by the primary ionizing particle. As the gas amplification within the counter tube is greater than 1 (probably less than 10^5) the electronic amplification



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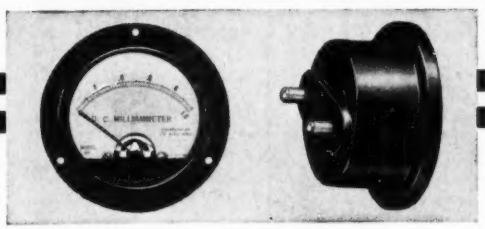

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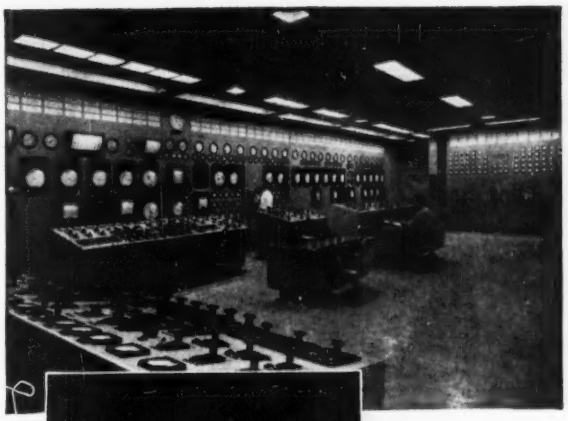

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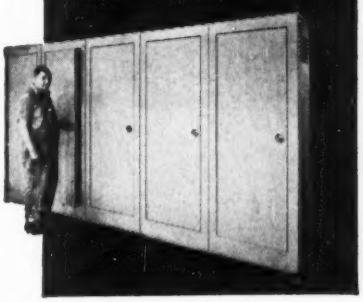

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necessary for recording the signal is less than for the ion chamber.

The anode (Fig. 3-2) is on the order of 1/1000 of the diameter of the cathode and coaxial with it. A potential of, let us say, 3000 volts is placed across the electrode system, establishing an electric field. Owing to the coaxial geometry, the gradient increases exponentially as the anode is approached.

When an ionizing particle passes through the gas, the particle sets up a chain of multiple ionizations (the Townsend avalanche). The result is an output signal that may be one thousand times that obtained from a conventional ion chamber. This increase in the magnitude of the signal due to gas amplification makes the circuitry associated with a proportional counter tube less complex than that associated with an ion chamber. In addition, as the signal is proportional to the number of ions formed by the radiation, discrimination between various types of radiation can be achieved by proper circuitry. Moreover, the speed of operation of a proportional counter is limited only by its electronic circuit. Owing to these advantages the proportional counter is used widely in quantitative laboratory studies.

Geiger-Mueller Counters

A Geiger-Mueller counter, like a proportional counter or ion chamber (Fig. 3-2), is a system of electrodes (usually consisting of a cylinder and concentric wire) in a gas. The center wire is at a positive potential with respect to the cylinder. Under suitable conditions an ionizing event may produce ions in the gas, and the ions may in turn create between the electrodes a uniform voltage pulse independent of the number of ions formed by the initial ionizing event. The signal from a Geiger-Mueller tube usually is one thousand times greater than that from a proportional counter, being on the order of a few volts. Consequently, a rather simple recording circuit is required when a Geiger-Mueller counter is used for the sensing element. As a result, this type of counter is in frequent use. It has, however, certain disadvantages. It cannot readily discriminate between different types of radiation, nor can it give a linear response versus wave length. Moreover,

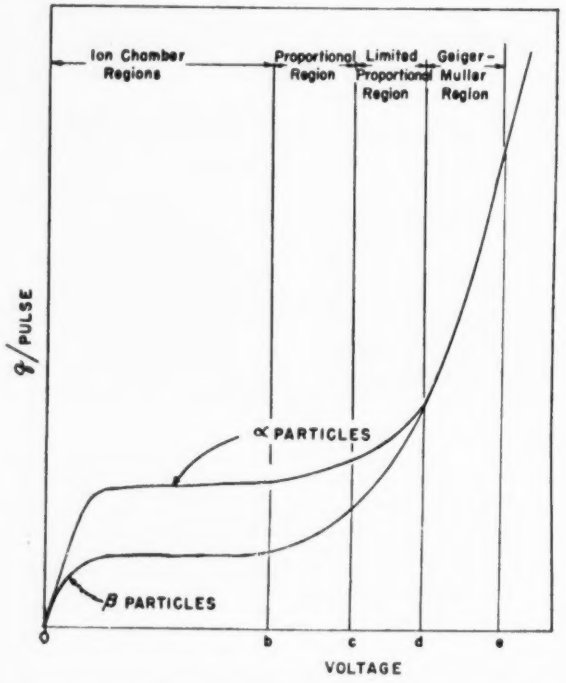

Fig. 3-5. Curves showing output from sensitive chamber (per pulse) versus voltage applied across electrodes. Shown are the regions in which the sensing element operates as either ion chamber, proportional counter, or Geiger-Mueller counter.

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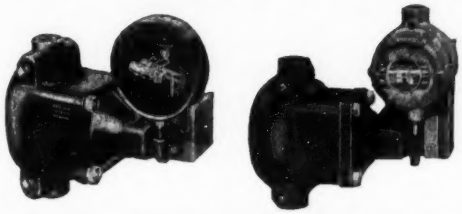

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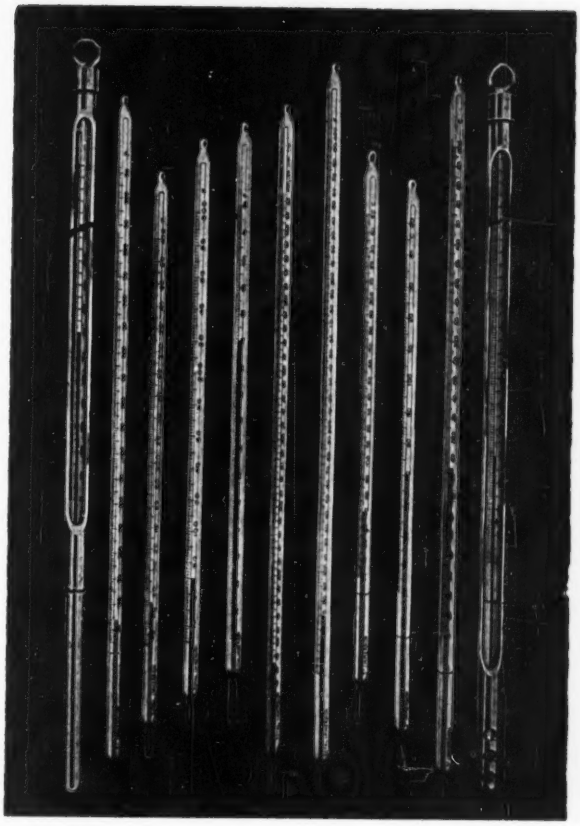

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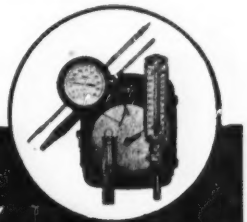

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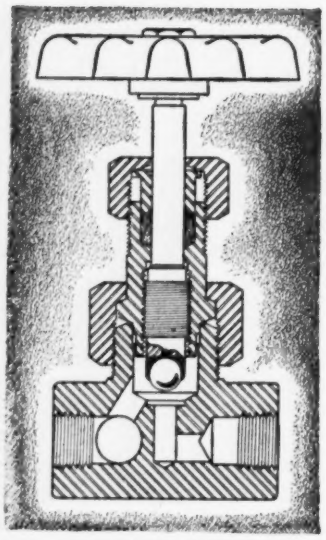

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its operation is some one hundred times slower than that of a proportional counter. Owing to its initial cost, however, as well as the other advantages noted, the Geiger-Mueller counter is today the most widely used sensing unit.

Note that an ion chamber, a proportional counter, and a Geiger-Mueller counter are similar in principle. Fig. 3-5 shows the differences in operation. In Fig. 3-5 charge per pulse is plotted versus voltage (electrical gradient) between anode and cathode. As the voltage between these two elements is increased above zero, the electrons and positive ions caused by the passage of a charged particle through the gas, separate and migrate to the anode and cathode respectively. The charge per pulse in the ion-chamber region increases until the effect of "saturation" occurs—that is, until all ions from each event are collected. From then on, there is a flat region. Fig. 3-5 shows two curves, the lower from a beta particle and the upper from an alpha particle. The charge per pulse is greater for the alpha particle in the ion-chamber region because of the greater specific ionization of the alpha particle. As long as the gain within the counter gas is one, the sensing element is in the ion-chamber region. However, as soon as gas multiplication occurs, the phenomenon is described as the *proportional region*. Where the alpha and beta curves coincide, the *Geiger region* begins. As the electrical gradient increases, the type of ionizing radiation no longer influences the charge collected per pulse. Ion chambers, proportional counter tubes, and Geiger-Mueller tubes are available in many sizes and shapes, as shown in Fig. 3-9.

Geiger-Mueller counters, like all gaseous-sensing-element instruments, are insensitive to gamma rays and have about one percent of the efficiency found for the ideal case of beta radiation.

Scintillation Counters

A scintillation counter is a transducer composed of a fluorescing crystal (or a non-crystalline solid or a fluorescing solution) and a photomultiplier tube. The crystal transposes radiation of short wave-length into ultraviolet or blue light. These tiny flashes, which are composed of photons, strike a photosensitive surface and thus cause electrons to be emitted into an imposed electric field (Fig. 3-6). The electrons, striking a dynode (C_1) at a positive

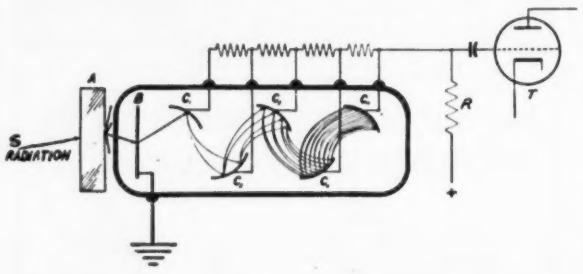

Fig. 3-6. Scintillation counter, showing fluorescing crystals (A), photomultiplier tube, and amplifier tube (T), which can be connected to a scalar-type indicator.

potential, emit a number of electrons greater than the number which has arrived. Striking the next dynode C_2, which is at still higher potential, the electrons increase their number through the principle of secondary emission. With their arrival at the final dynode in this cascade process, a signal of about 1/50 volt is emitted at the output of the dynode system (called a photomultiplier tube). This signal is amplified and recorded.

The advantages of scintillation counters are extreme speed of operation and high efficiency in the detection of gamma radiation, to which they are approximately fifty times as sensitive as are Geiger-Mueller and proportional counters. Scintillation counters are capable of speeds approximately four hundred times as great as that of Geiger-Mueller counters. A disadvantage of photomultiplier tubes is their response-dependency upon various parameters. A further

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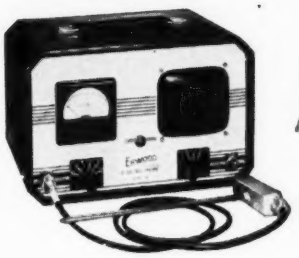

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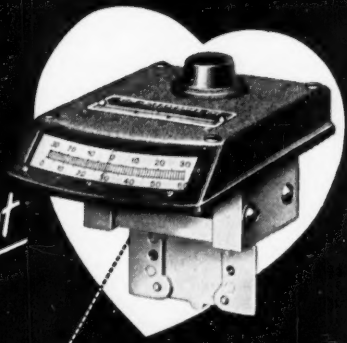

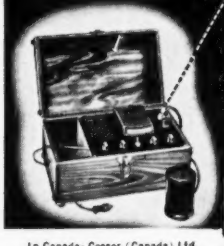

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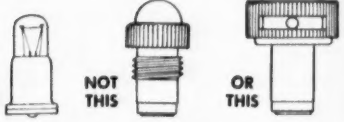

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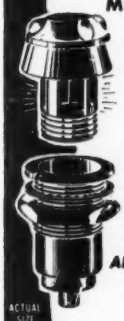

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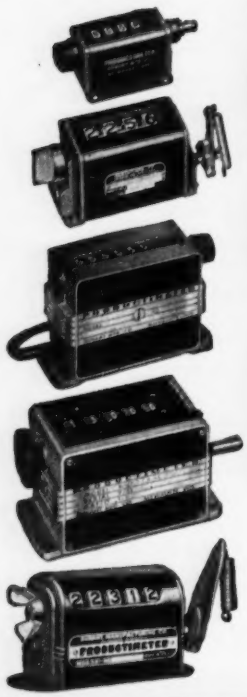

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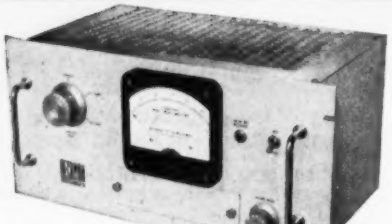

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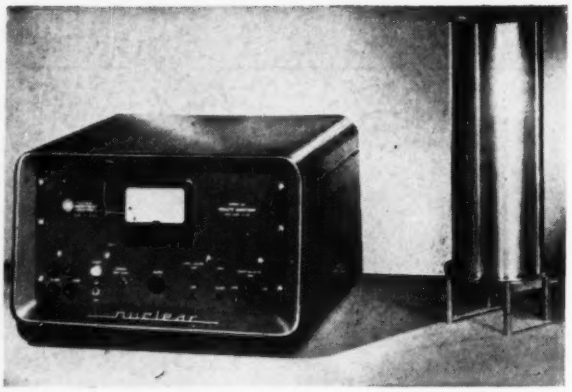

Fig. 3-7. Typical radiation survey meter of ionization-chamber type, using direct-coupled electrometer amplifier and D'Arsonval-type indicator. Instrument is used for measurement of high gamma or neutron flux near reactors or accelerators. (Photo courtesy Nuclear Instrument & Chemical Corp.)

disadvantage is, in certain cases, their background. But with special improvements the scintillation counter tube may become one of the most important instruments in detecting radiation.

Reading Device

Sensing elements require a reading device or recording element. Usually electronic in nature, the indicator provides both amplification of the signals and an electro-actuation of a mechanical register.

Recording Element for Photographic Film, Chemical Integrating Indicators, and Cloud Chambers

Photographic film which has been exposed to radiation can have its opaqueness recorded in a *photometer*. Its opacity then is correlated with the opaqueness resulting from exposure to a known quantity of radiation; thus the amount of radiation absorbed by the test film is recorded.

To record the quantity of radiation absorbed by a chemical indicator, one visually compares the color of the irradiated liquid or solid with the color of liquids or solids which have been exposed to known amounts of radiation.

In cloud chambers a photograph is taken of the track left by the ionizing radiation.

Reading Element for Ion Chambers

Whereas proportional counters and Geiger-Mueller counters are single-event devices, ion chambers produce a current—that is, the electrons arriving at the anode are treated not as distinct particles (as in counters) but as a current. Large ion chambers thus have an amplifying circuit of the direct-coupled type (Fig. 3-2); there is no capacitor between the ion chamber and the electronic circuit in the first amplification stage. The amplified current, which is proportional to the radiation flux, is read from a current meter, generally of the D'Arsonval type. Fig. 3-7 shows a typical survey meter of ionization-chamber type, which uses direct-coupled electrometer-type amplifier and a D'Arsonval-type indicator. Fig. 3-8 shows an ion-chamber-type monitor with an electrostatic-voltmeter type of indicator.

Reading Element for Conducting Detectors, Proportional, Geiger-Mueller, and Scintillation Counter Tubes

Where counter tubes are used, the reading element usually consists of an amplifier which can handle high frequencies, a scaling circuit, and an indicator. A scaling circuit may be defined as an electronic circuit which divides by a constant factor the number of incoming repetitive signals, which then are indicated by a mechanical device. The scaling circuit may be based on the number two (binary stage) or on the number ten (decade stage); both systems are used widely. The decade system appears to be more critical as to components.

Rate meters sometimes are used instead of scaling cir-

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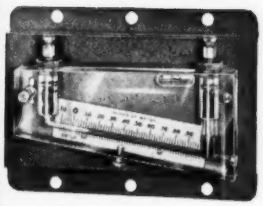

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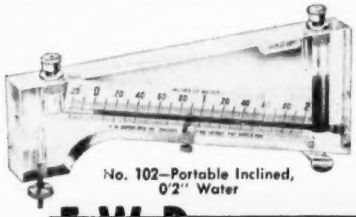

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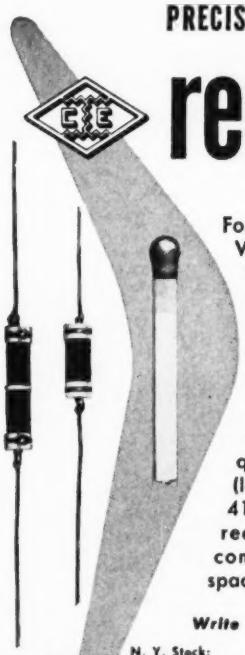
resistors



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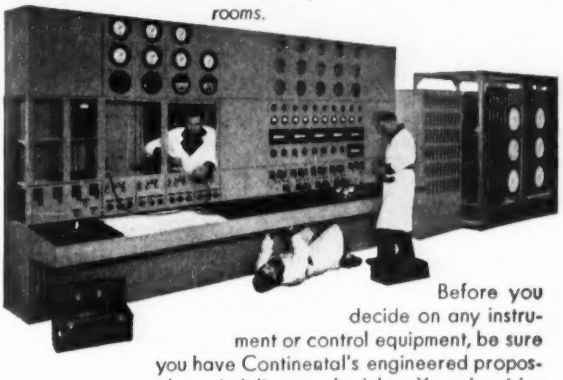

Before you decide on any instrument or control equipment, be sure you have Continental's engineered proposals and delivery schedules. Your inquiries will be given prompt attention . . . and you'll get into action . . . fast!

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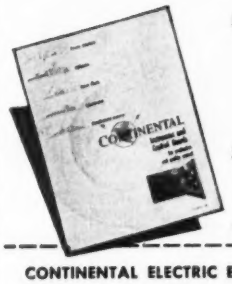

BULLETIN 700

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Small Motors

accurately maintain
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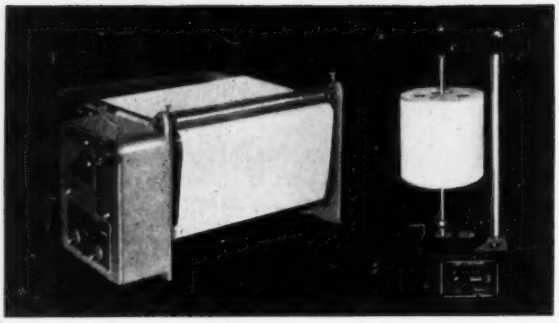

Phipps & Bird, Inc. of Richmond, Virginia standardizes on the Barcol unidirectional HYAZ geared-head motor for driving their kymographs. If you make instruments calling for *precision* operation, let Barber-Colman engineers help solve your problem with a rugged, high-torque Barcol motor. Line includes unidirectional, synchronous, and reversible motors . . . with or without reduction gearing . . . up to 1/30 hp.

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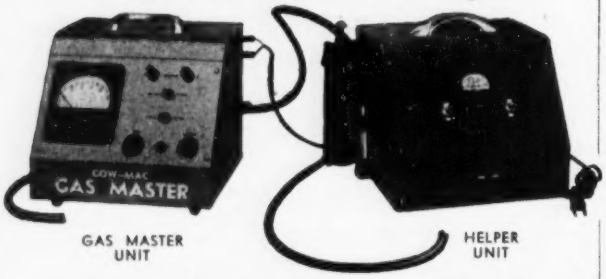

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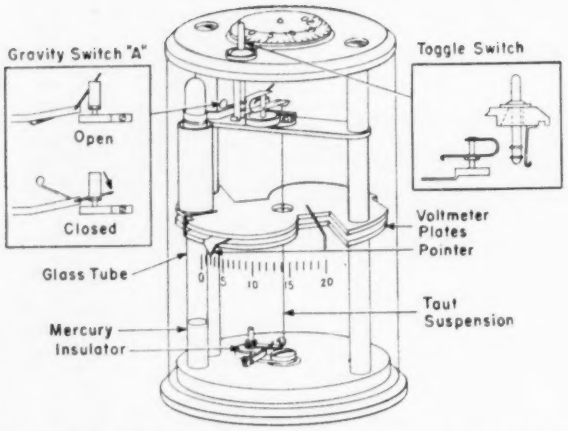


Fig. 3-8. Radiation monitor containing no tubes, power supply, or batteries. Monitor comprises ionization chamber, electrostatic voltmeter, and an electrostatic charge generator. When monitor is turned upside down, the mercury pellet slides inside the glass tube and generates a frictional charge, which charges the moving-vane-type electrostatic voltmeter. The radiation to be detected ionizes the air inside the monitor, reduces the charge, and moves the pointer. (Courtesy General Electric Co.)

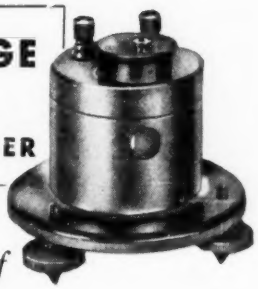
cuits. A rate meter may have either linear or logarithmic scales. For the various types of counter sensing elements, only the input amplifier varies with the change in element. Fig. 3-9 illustrates a reading instrument of the scaler type, which can be connected to nearly all types of sensing elements, as the photograph suggests.

Reading elements for pulse-registering devices may have *coincidence* and *anti-coincidence* circuits. A coincidence electronic circuit uses two or more sensing elements. If the register operates only when the two sensing elements are activated by the same particle of radiation, the sensing elements are said to be operating in coincidence. If, however, the circuit is arranged so that the two sensing elements operating from the same energy particle fail to cause the register to record, then the circuit is said to be anti-coincident. Coincident and anti-coincident circuits are used in cosmic ray and other laboratory studies to blank out an undesired resultant, to achieve a directional effect, or to study decay schemes of isotopes.

Knowledge of the types of nuclear radiations and of the instruments and electronic circuitry connected with them is of great importance to an industry or a university considering the installation of a reactor. Closely related to the subject of radiations is the problem of protection against injury from radiations; this subject is treated by Dr. Karl Z. Morgan in the next installment of this series.

Fig. 3-9. A few of the many types of ion chambers, proportional counters, and Geiger counter tubes which can be connected to a scaler-type indicator. The scalar-type indicator (shown at rear) contains pulse amplifier, power supply, scaling circuits, and indicators. (Photo courtesy Radiation Counter Laboratories, Inc.)

CAMBRIDGE "FLIK" GALVANOMETER



—a sensitive galvanometer of rapid response

This instrument is especially suited for work where high sensitivity combined with rapid response is required. May be used with lamp and scale or photographic recorder. Performance data for periodic time of 0.1 second is shown below, but instruments are available for shorter periods down to approximately 0.02 second.

Coil Resistance ohms	Periodic time Seconds	Sensitivity m.m./μA at 1 meter	External Resistance for Critical Damping
300	0.1	100	4000
20	0.1	20	100

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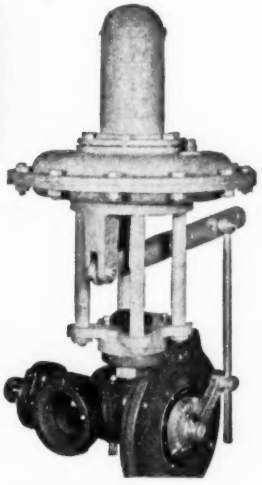

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AGASTAT

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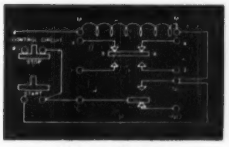
TIME DELAY RELAYS with Remote Push Button Control



Wiring diagram
NEH-11 AGASTAT

An auxiliary "hold-in" switch affixed to the bottom of these pneumatic relays makes possible a remote push button control of the time delay. Delays easily adjustable from 0.1 second to 10 or more minutes. A.C. and D.C. units, single or double break contacts. All are lightweight, compact, easily mounted and low in cost.

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Pioneers in pneumatic timing

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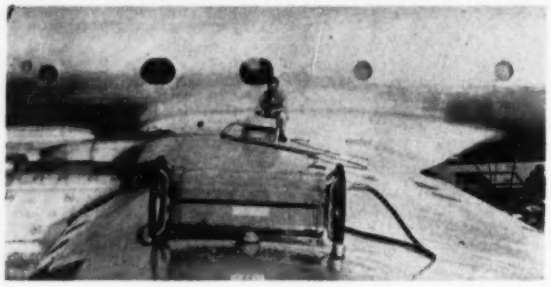
INSTRUMENTS ON THE MARCH

New Principles, Applications, Non-commercial Developments

Radiographic Inspection

BURBANK, CALIF.—X-ray inspection of internal structural members of airplanes now is used by Lockheed Aircraft Corporation, Burbank, Calif. Dry and cracked chro-



mate paint on the inside surface of a wing has been detected, as have fatigue cracks, sheared bolts and rivets, and buckled ribs. Shown in use is the "Andrex" portable equipment of Holger Andreasen, Inc., San Francisco.

Texas A & M Symposium

COLLEGE STATION, TEXAS—The Agricultural and Mechanical College of Texas will hold its ninth Symposium on "Instrumentation for the Process Industries" on January 27, 28, and 29, 1954. Information, including a program announcement, may be obtained from Professor C. D. Holland, Chemical Engineering Department, Texas A & M College, College Station, Texas.

Cardiogram Telemetering

OMAHA, NEB.—The University of Nebraska now provides a consultation service that permits a physician with a heart patient in any part of the state to send a cardiogram via telephone to the University's laboratory in Omaha. Specialists in the laboratory interpret the electro-cardiogram and provide diagnosis within an hour.

The apparatus for the new service, originally called the "Automatic Recording Electro-Cardiograph Monitor," uses FM recording on standard magnetic tape. The signals are then sent via regular long-distance telephone lines to the laboratory, where they are re-recorded for analysis. Modifications permit use of the apparatus for brain waves.

Record Attendance At WESCON

Engineers, scientists, and technicians to a record total of nearly 14,000 registered for technical sessions and exhibits at the 1953 WESCON (Western Electronic Show and Convention) during the three-day run in the San Francisco Civic Auditorium, August 19-21. Approximately 1500 attended the technical sessions; 12,500 others visited the 370 displays.

The show, co-sponsored by the Seventh Region IRE (Institute of Radio Engineers) and WCEMA (West Coast Electronic Manufacturers' Association), displayed for the first time this year a new exhibit of Western historical electroniana, including early electron tubes, communication equipment, and pioneer electronic activities.

Featured at the convention were 125 technical papers distributed through 25 sessions, including two each on computers, transistors, circuits, audio, propagation, antennas, microwave techniques, instrumentation, electron devices, and servo systems; and one each on color television, airborne electronics, noise, nuclear electronics, and medical electronics. Special interest was attached to the evening sessions on Thursday and Friday which covered the topic of color television and the new NTSC standard system, and the session on the rapidly-expanding field of medical electronics.

At the All Industry Luncheon, *Donald G. Fink*, Director of Research, Philco Corporation, summed up the history,

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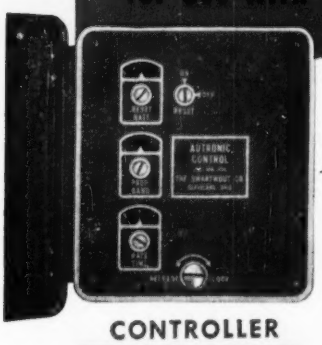
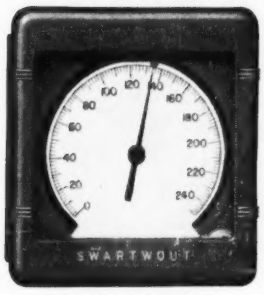
New Autronic

THERMOCOUPLE CONVERTER

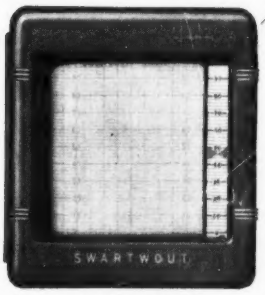
for use with miniature instruments



CONTROLLER



INDICATOR



RECORDER

Exhibited for the first time at the recent Chicago Instrument Show, the Swartwout Autronic Thermocouple Converter is now in production. Designed primarily for use with components of the Autronic system, it is a high impedance all-electronic null-balance unit which does not draw current from the thermocouple. D-c millivolt signals are converted to 0.000-0.500 volt a-c. Range is easily and quickly converted by changing range cards. There are no pilot valves, flappers or other troublesome parts. Operation is instantaneous, maintenance virtually eliminated.

CONDENSED SPECIFICATION DATA

SPAN: 2 to 50 millivolts
ZERO SUPPRESSION: −10 to +50 millivolts
SPAN ACCURACY: ½%
SUPPRESSION ACCURACY: 0.1%
REPRODUCIBILITY: ¼%
SENSITIVITY: 0.1%
REFERENCE JUNCTION COMPENSATION: Automatic—Removable card for different thermocouple materials
SPAN AND ZERO ADJUSTMENT: Replaceable range card
REFERENCE VOLTAGE: Standard cell
INPUT IMPEDANCE: Null-balance—draws no current
OUTPUT VOLTAGE: 0.000 — 0.500 volts, 60 cycles a-c
CASE: Surface mounting

Other Swartwout a-c and d-c converters are available for use with primary elements such as pH, oxygen, strain gage, electronic flowmeter, cascading, ratioing, etc. Literature and information available on request to Swartwout representatives or to the plant. A-8611

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For engineering data, write for K Bulletin. For a general survey of entire Cannon line, request Cannon Plug Guide.

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INSTRUMENTS ON THE MARCH

Continued from page 1760

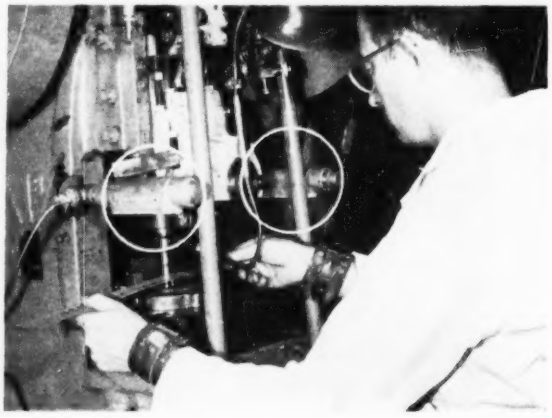
achievements, and present status of semiconductor devices in a speech titled "The Transistor . . . Glamor Boy or Work Horse?" Mr. Fink pointed out "that in the five years since the transistor was first announced, only two commercial applications foreseen have come to pass. It is used in telephone exchanges and is begining to find use as an amplifier in hearing aids.

"However, after many false starts, excursions and alarms, the transistor has reached the threshold of maturity and in the next five years will probably have gained the reputation as being a workhorse."

Next year's show will be held at the Pan Pacific Auditorium in Los Angeles, Calif., Aug. 25-27, 1954.

Radioisotopes Protect Operators

SAN FRANCISCO, CALIF.—Installation of an "atomic" safety device, first of its type, to protect the hands of punch-press operators at the San Francisco maintenance base of United Air Lines has been announced. Operators of the



accident-proof punch press wear wristbands containing radioactive crystals. Three Geiger tubes (circled) enclose the punching area—one at the front and one on each side of the zone where injuries can occur. If hands stray into danger, the tubes pick up radiation from the wristbands and instantly halt the machine. The device can stop the punch in mid-stroke.

As a further safety measure, the punch press will not run unless the operator is equipped with the wristbands. Hazatrol Incorporated of Berkeley, California, designed the unique safety device.

Scale Calibrates Flowmeters

WARREN, MICH.—General Motors Technical Center of Warren, Mich. is using a photoelectric-controlled timer and scale to accurately calibrate liquid flowmeters. The time for an exact weight of fuel to flow is indicated directly on a timer, which is controlled automatically by the output of the photoelectric control on the scale. The scale with integral photoelectric controller is made by Exact Weight Scale Co., Columbus 8, Ohio.

Spectrometer Tests Magnets

EDMORE, MICH.—Carboloy Department of General Electric Company of Detroit uses every type of testing

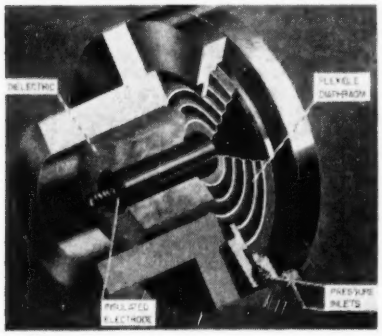
and inspection instrumentation on its new permanent-magnet production line at Edmore, Mich.—from inspection of incoming foundry-sand particle size to ballistic-galvanometer testing of the field strength of the finished magnet. One interesting new test, said to be the only one in the industry, is use of a direct-reading spectrometer to check chemical analysis of every batch of melted metal, providing a quality-control check five minutes after the sample is placed in the electronic equipment. All permanent-magnet heats are checked. Operator is shown using the direct reading spectrometer.

Radioisotopes In Tubes

BOSTON, MASS.—Tracerlab, Inc. of Boston reports that radioisotopes are now helping several large New England manufacturers build better switching and gas tubes for use in radar, computers, and other electronic equipment. By placing a minute drop of a radioactive cobalt solution on the tube electrodes, the tube fires more quickly, reducing time lags in operation.

Micromanometer

WASHINGTON, D. C.—A highly sensitive micromanometer, designed to measure differential pressures as low as 0.03 micron of mercury with resolutions of the order of 0.001 micron Hg, has recently been developed by T. A. Perls, W. H. Kaechele, and D. S. Goalwin of the National Bureau of Standards.



The micromanometer consists of a 3-inch-diam. corrugated diaphragm (made of brass sheet 0.001-inch thick) mounted in a shallow cylindrical cavity. The diaphragm divides the cavity into two pressure-tight chambers. An insulated electrode passes through the top of the cylinder to become one side of a variable capacitor; the flexible diaphragm forms the other side of the capacitor, which has a nominal capacitance of about 20 micromicrofarads. Changes in either temperature or pressure within one of the cavities will cause the diaphragm to flex and move, changing the capacitance of the system. The electrode-diaphragm-cavity section forms the fourth arm of a resonant capacitance bridge driven from a 500-kc. crystal oscillator.

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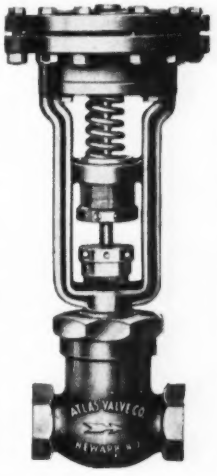
Type "D" REDUCING VALVES

The exceptional valve shown here is our ATLAS Type "D". In our 52-page Bulletin 1-A it is shown as Fig. 171. If you need reducing valves be sure to ask for Bulletin 1-A as it gives complete information concerning a wide range of regulating valves for steam, water, air, gas or oil. Ever since its introduction Type "D" has made a "hit" with engineers. It is unusually simple. Gives accurate and close regulation of pressures. Is easy to inspect. Stainless steel or bronze seat rings, stainless steel or composition discs. Stainless steel valve stem. Removable diaphragm top. Adaptable to steam, air, or gas. Good for up to 300 lb. initial pressure. Durable. Body of bronze. Screwed or flanged ends.



WHAT'S YOUR REGULATING PROBLEM?

For best results, whatever your regulating problems may be, form the good habit of always placing them in the hands of ATLAS engineers. Your requirements will be given their competent and prompt attention. For more than a half century ATLAS has been specializing solely in regulating valves. Type "D," shown here, is a result of that specialization.

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REGULATING VALVES FOR EVERY SERVICE
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Campbell Boiler Feed Regulator
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Control Temperatures

within a

Fraction of a Degree

That's close enough for the most critical control requirements. Actual performance demonstrates that it is being done with a simple electrical unit—automatically. No attention is needed, the operator simply selects the control point on the controller.

A Gordon XACTLINE in the control circuit actuates the control before the set temperature is reached (up or down). The short on-off cycle (as short as three seconds) thus produced will give extremely close control. Because it's electrical—with no dependence on gears, cams, shafts, etc.—it is accurate and reliable.

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Gordon XACTLINE can be placed in the control circuit of any fuel-fired or electrically heated oven, furnace, kiln, injection molding machine, etc. Once installed, no adjustment or coordination with the control instrument is required regardless of size of furnace, length of heating cycle, or density of load. It can be used equally well with any existing indicating or recording standard pyrometer controller, regardless of age.

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MANUFACTURERS' NEW LITERATURE

In this department we report new literature, pertaining to instrumentation, received from the manufacturers. We urge readers to request ONLY those bulletins which will be of value to them. Use the Postage-free Order Card on Page 1787.

Requests for literature FROM ABROAD should be made on company letterhead and mailed DIRECTLY to the manufacturers.

PROCESS CONTROL

Industrial Process Instrumentation. New 48-page illustrated issue Vol. 6, No. 6 of "Instrumentation" presents articles on blast-furnace pressure control, recovering hydrocarbons, optics and appearance instrumentation, amperometric titration, instrumentation in synthetic textile industries, etc.—Minneapolis-Honeywell Regulator Co., Industrial Div., Phila. 44, Pa.

Circle **601** on inquiry card.

Pneumatic Transmission Instruments. New 4-page illustrated Bulletin A106 gives features of maker's "Metagraphic" pneumatic transmission instrument system for process control.—Bristol Co., Waterbury 20, Conn.

Circle **602** on inquiry card.

Side-register Control Systems. New 8-page illustrated Bulletin GEA-5947 lists uses, features, and components of maker's side-register control systems for slitting, printing, etc.—General Electric, Schenectady 5, N. Y.

Circle **603** on inquiry card.

Waste Water Treatment. New 4-page issue Vol. 2, No. 9 of "Ratonews" gives illustrations and description of treatment of process and domestic waste water at large food processing plant.—Fischer & Porter Co., Hatboro, Pa.

Circle **604** on inquiry card.

Narrow-band Controller. New 2-page illustrated Bulletin 504-S presents features, applications, and components of maker's "Air-O-Line" pneumatic control for circular chart controllers, which features narrow proportional band and reset.—Minneapolis-Honeywell Regulator Co., Industrial Div., Phila. 44, Pa.

Circle **605** on inquiry card.

Electro-Hydraulic Relay. New 1-page Bulletin 157-A presents features, performance and applications of maker's "Electro-Jet" power package, a new type of electro-hydraulic relay for high-speed positioning of heavy dampers, doors, etc.—Askania Regulator Co., 240 E. Ontario St., Chicago, Ill.

Circle **606** on inquiry card.

Clinker Cooler Instrumentation. New 4-page illustrated Bulletin 1.1-3 gives theory and practice of automatic control of inclined grate clinker coolers, including bed depth, temperature and pressure.—Minneapolis-Honeywell Regulator Co., Industrial Div., Phila. 44, Pa.

Circle **607** on inquiry card.

Sewage Chlorination. New 2-page Information Sheet 810-J37 gives purposes, types, points of application, modes of control, types of feed, types of feeders, and location of equipment for Sewage chlorination.—Builders-Providence, Inc., 345 Harris Ave., Providence, R. I.

Circle **608** on inquiry card.

Combustion Control. New 4-page illustrated bulletin describes maker's line of automatic combustion controls, including master regulators, draft regulators, fuel-air ratio controllers, smoke alarms, etc.—Standard Instrument Corp., 350 Fifth Ave., New York, N. Y.

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Boiler Control. New 4-page bulletin and selection chart lists features and applications of maker's water level and pressure safety controls for industrial use.—McDonnell & Miller, Inc., 3500 N. Spaulding Ave., Chicago, Ill.

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Ventilating Control. New 4-page Bulletin F 6166 describes and illustrates maker's electronic controls for heating, ventilating, and air conditioning.—Barber-Colman Co., Rockford, Ill.

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Vertical-scale Indicator. New 8-page illustrated Bulletin 1541 describes and presents features, specifications, and components of maker's vertical-scale indicator for applications where panel space is at a premium.—Minneapolis-Honeywell Regulator Co., Industrial Div., Phila. 44, Pa.

Circle **612** on inquiry card.

Steam Equipment. New 12-page illustrated Catalog 400 describes maker's line of separators, exhaust heads, traps, strainers, and boiler trimmings.—Wight-Austin Co., 3245 Wight St., Detroit, Mich.

Circle **613** on inquiry card.

SERVOS

Synchros, Servo Motors. New 80-page catalog lists and describes maker's line of synchros, resolvers, servo motors, transmitters, and gives advance engineering data on tachometer-generator, linear synchro control transformer, and other synchro components.—Ketay Mfg. Corp., 555 Broadway, New York, N. Y.

Circle **614** on inquiry card.

Servo System, Components. New 4-page illustrated Bulletin 10.20-3a presents applications, specifications, dimensional data and table of typical servo combinations using maker's motors and amplifiers.—Minneapolis-Honeywell Regulator Co., Industrial Div., Phila. 44, Pa.

Circle **615** on inquiry card.

Servo Lead Networks. New 6-page illustrated Bulletin 410 presents response curves, circuit data, and tabulations of standard types of servo lead networks.—White Instrument Labs., 203 Riverside Dr., Austin, Texas.

Circle **616** on inquiry card.

VALVES

Solenoid, Check Valves. New 54-page Catalog 200 describes and illustrates maker's "Marotta" valves for aircraft, guided missiles, and general industrial uses. Includes lines of solenoid valves, check valves, pressure-operated valves, etc.—Robertshaw-Fulton Controls Co., Bridgeport Thermostat Div., Bridgeport 1, Conn.

Circle **617** on inquiry card.

Valves. New 72-page illustrated Catalog 2 lists applications and features of maker's needle valves, toggle valves, packless valves, pressure regulators, and accessories for fluid control.—Hoke Inc., Englewood, N. J.

Circle **618** on inquiry card.

Pressure-operated Valves. New 2-page Bulletin D-53 describes and illustrates maker's "Type D-53" diaphragm-operated valves.—A. W. Cash Valve Mfg. Corp., 666 E. Wabash Ave., Decatur, Ill.

Circle **619** on inquiry card.

Cylinder-type Valve Actuators. New 4-page Bulletin 3000 gives features and general data on maker's pneumatic and hydraulic cylinder-type valve actuators.—Ledeen Mfg. Co., 1600 S. San Pedro St., Los Angeles, Calif.

Circle **620** on inquiry card.

Diaphragm-type Hand Valve. New 2-page illustrated Bulletin 3021 lists features and dimensions of maker's "Red Head" diaphragm-type packless valve.—Imperial Brass Mfg. Co., 1200 W. Harrison St., Chicago, Ill.

Circle **621** on inquiry card.

Hydraulic Servo Valve. New 2-page brochure presents maker's non-jamming 2-stage servo valve with magnetic operation and up to 14-hp. output.—Sanders Associates, Inc., 137 Canal St., Nashua, N. H.

Circle **622** on inquiry card.

Pressure Relief Valves. New 24-page Booklet, "Selection and Sizing Pressure Relief Valves to Comply With ASME Boiler Code Requirements" gives formulae and tables for determining gross heat output of all types boilers, tanks, and heaters.—McDonnell & Miller, Inc., 3500 N. Spaulding Ave., Chicago, Ill.

Circle **623** on inquiry card.

Four-position Valve. New 4-page illustrated Brochure 600 presents function, operation, design, construction, features, and application of the maker's "Cycloflow Valve" for controlling ion-exchange cycles.—American Water Softener Co., Inc., Fourth & Lehigh Ave., Phila., Pa.

Circle **624** on inquiry card.

Diaphragm-valve Specifications. New 4-page Bulletin SP-CV1 presents specifications for diaphragm control valves, representing a study of valve users. Includes topworks, body, trim, bonnets, positioner, and inspection.—Delaware Valley Engineering Co., 3326 Lancaster Ave., Phila., Pa.

Circle **625** on inquiry card.

TEMPERATURE

Thermocouples, Resistance Bulbs. New 42-page illustrated Catalog TC 10 gives features of maker's thermocouples, radiation detectors, and resistance bulbs. Also treats how to make thermocouples, and includes 12 charts of thermocouple calibration data and directions.—Wheelco Instruments Div., Barber-Colman Co., Rockford, Ill.

Circle **626** on inquiry card.

Thermistors. New 8-page Bulletin and 2-page data sheet TH-10 give features, characteristics and applications of maker's thermistors.—Carboloy Dept., General Electric Co., Detroit 32, Mich.

Circle **627** on inquiry card.

Temperature Monitor. New 6-page illustrated Bulletin 3036 gives working principle, features, and dimensions of maker's new "Omniguard" indicating and alarm system.—Thomas A. Edison, Inc., West Orange, N. J.

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Photoelectric-magnetic Temperature Controller. New 4-page illustrated bulletin presents features, characteristics, functions, and specifications of maker's stepless electric controller that uses vane-photocell input and magnetic-amplifier output to

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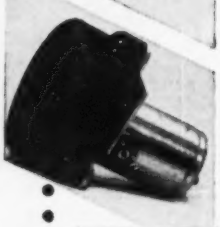

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control temperature or current.—West Instrument Corp., 525 N. Noble St., Chicago, Ill.

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Electronic Temperature Controller. New 2-page illustrated brochure presents features of maker's automatic "Alnor" electronic temperature controller.—Illinois Testing Laboratories, Inc., 420 N. LaSalle St., Chicago, Ill.

Circle **630** on inquiry card.

Temperature Control. New 8-page illustrated issue of "Modern Precision," (Vol. 13, No. 2) features articles describing maker's temperature control equipment and "Speedomax" recorders in practical use in pottery plant, jet testing, steel heat treating, and ocean current measurement.—Leeds & Northrup Co., 4907 Stenton Ave., Phila., Pa.

Circle **631** on inquiry card.

Resistance Thermometers. New 2-page illustrated Bulletin 10.1-3 gives operating principle, applications, equipment required, features, and installation of maker's "RdF Stikon" resistance thermometer.—Minneapolis-Honeywell Regulator Co., Phila. 44, Pa.

Circle **632** on inquiry card.

Portable Temperature Controller. New 2-page illustrated Bulletin JE-1 presents features and specifications of maker's new portable temperature controller for laboratory use.—West Instrument Corp., 525 N. Noble St., Chicago, Ill.

Circle **633** on inquiry card.

Hand Pyrometer. New 4-page illustrated Bulletin GEA-6020 lists uses, specifications and applications for maker's portable pyrometer for measuring temperature of any surface, liquid, gas or molten metal from 0 to 1500 deg. F.—General Electric, Schenectady 5, N. Y.

Circle **634** on inquiry card.

Dial Thermometers. New 16-page illustrated Bulletin 467 gives principles of operation, features, application, and description of maker's dial thermometers for measurements at long distances.—Foxboro Co., Foxboro, Mass.

Circle **635** on inquiry card.

Temperature Controls. New 4-page Catalog G-18 presents maker's line of temperature controls that use differential-expansion members to operate snap-action switch.—Burling Instrument Co., 5 Vose Ave., S. Orange, N. J.

Circle **636** on inquiry card.

Thermocouples, Supplies. New 24-page illustrated Catalog 12 lists features and dimensions of maker's thermocouples and thermocouple supplies, including heads, insulators, wire, etc.—Industrial Pyrometer & Supply Co., Alton, Ill.

Circle **637** on inquiry card.

Thermocouple Harnesses. New 4-page bulletin describes and illustrates maker's custom-made harnesses for temperature measurement.—Thermal Harness Co., Meriden, Conn.

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PRESSURE

Molecular Vacuum Gage. New 4-page Bulletin GEC-986 describes and illustrates maker's new molecular vacuum gage that uses energy transfer from constant-speed vaned cylinder to restrained vaned cylinder, via atmosphere to be measured, as measure of atmosphere pressure.—General Electric, Schenectady, N. Y.

Circle **639** on inquiry card.

Differential Converter Transmitter. New 4-page illustrated Bulletin 2290 gives features, design principle, and specifications of maker's pneumatic force-balance-principle operating differential converter and transmitter.—Minneapolis-Honeywell Regulator Co., Ind. Div., Phila. 44, Pa.

Circle **640** on inquiry card.

Manometer. New 2-page bulletin describes and illustrates maker's U-type, clean-out manometer for measuring pressure, vacuum, or differential pressure. Includes principles and basic uses.—King Engineering Corp., Ann Arbor, Mich.

Circle **641** on inquiry card.

High-frequency Pressure Cells. New 2-page Bulletin 4107 presents uses and specifications of maker's SR-4 high-frequency pressure cells for measurement of rapidly changing pressures up to 20,000 lb./sq. in.—Baldwin-Lima-Hamilton Corp., Phila. 42, Pa.

Circle **642** on inquiry card.

Pressure, Acceleration Pickups. New 2-page Bulletins 508, 408, and 602A give description and specifications of maker's differential-pressure potentiometer, absolute-pressure potentiometer, and acceleration potentiometer.—Bourns Labs., 6135 Magnolia Ave., Riverside, Calif.

Circle **643** on inquiry card.

Low-pressure Transducer. New 2-page illustrated bulletin gives features, specifications and dimensional drawings of maker's "Model-L" low-pressure transducers that use bellows and beryllium copper flexure members to activate a potentiometer.—Servonic Instruments, 1193 W. Second St., Pomona, Calif.

Circle **644** on inquiry card.

High-pressure Switch. New 2-page illustrated bulletin gives operating principle and representative test results of maker's "Kilotrol" high-pressure switch.—Cook Electric Co., 2700 N. Southport Ave., Chicago 14, Ill.

Circle **645** on inquiry card.

Pressure Instrument Isolators. New 2-page bulletin lists features and specifications, and gives dimensional drawings of maker's pressure instru-

ment isolators that protect instruments from corrosives.—Servonic Instruments, 1193 W. Second St., Pomona, Calif.

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Draft Regulator. New 4-page Bulletin C-101 describes and illustrates maker's automatic combustion control for oil, gas or coal fired boilers.—Reliance Instrument Mfg. Corp., 190 Glen Cove Ave., Glen Cove, L. I., N. Y.

Circle **647** on inquiry card.

High Vacuum Equipment. New 16-page illustrated bulletin describes and lists features, engineering data and specifications of maker's vane- and piston-type rotary gas-ballast pumps. Also explains theory and applications of gas ballast operation.—National Research Corp., 70 Memorial Dr., Cambridge 42, Mass.

Circle **648** on inquiry card.

FLOW

Mass Flowmeter. New 4-page illustrated Bulletin GEC-932 gives applications, features, operating principle, theory, specifications, and dimensional drawings of maker's mass flowmeter system for measuring aircraft jet-engine fuel flow.—General Electric, Schenectady 5, N. Y.

Circle **649** on inquiry card.

Linear Flowmeters. New 4-page illustrated Bulletin 153 lists features, applications and basic engineering principle of maker's "Vol-O-Flo" meter that uses viscous-flow principle for accurate gas-flow measurement.—National Instrument Labs, Inc., 6108 Rhode Island Ave., Riverdale, Md.

Circle **650** on inquiry card.

Controlled Volume Pumps. New 12-page illustrated Bulletin 653 gives capacities, pressures, materials of construction and operating details of maker's miniature controlled volume pumps.—Milton Roy Co., 1300 East Mermaid Lane, Phila., Pa.

Circle **651** on inquiry card.

Recording Thermo-Anemometer. New 2-page illustrated bulletin gives principle of operation, design, and features of maker's recording thermo-anemometer for recording low air velocities.—Illinois Testing Labs, Inc., 420 N. LaSalle St., Chicago, Ill.

Circle **652** on inquiry card.

Miniature Panel Integrator-Indicator. New 4-page illustrated Catalog 55-30 presents operation, features, and schematic diagrams of maker's "Ratographic" integrator-indicator for mounting on miniature instrument graphic panels.—Fischer & Porter Co., Hatboro, Pa.

Circle **653** on inquiry card.

Industrial Flow Meter. New 16-page illustrated Bulletin 500 gives operational, construction, accuracy data and general information on maker's industrial "Type MO" inferential meter.—Simplex Valve and Meter Co., Phila. 42, Pa.

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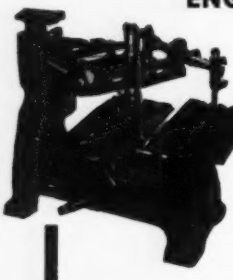

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NEW LITERATURE

1400) describe and illustrate maker's fuel flow transmitters, switches, summators, and indicators.—Revere Corp. of America, Wallingford, Conn.

Circle **655** on inquiry card.

WEIGHT

Weight Printer, Totalizer. New 10-page brochure presents features, operation, and typical applications of new "ETS-7" converter unit that converts weighing-scale output to input for adding machine.—Industrial Electronic Engineers, P. O. Box 25, Universal City, Calif.

Circle **656** on inquiry card.

Electronic Scale, Printer. New 4-page illustrated Data Sheet 10.18-4 describes electronic scale and printer for use in steel, chemical, and manufacturing industries for crane, conveyor, platform, hopper, or tank weighing.—Minneapolis-Honeywell Regulator Co., Industrial Div., Phila. 44, Pa.

Circle **657** on inquiry card.

Scales, Overload Signals. New 4-page illustrated Bulletin 19 E describes maker's overload switches and signals, dynamometers, universal testers, mechanical pressure gauges, weight indicators, and thermometers. —W. C. Dillon & Co., Inc., 14620G Keswick St., Van Nuys, Calif.

Circle **658** on inquiry card.

Continuous Weighing Belt Meter. New 4-page illustrated Bulletin 10.18-3 gives applications, principles and methods of operation of maker's "Trans Weigh Belt-Meter" for measuring steady flow of loose material on conveyor belt.—Minneapolis-Honeywell Regulator Co., Industrial Div., Phila. 44, Pa.

Circle **659** on inquiry card.

LEVEL

Level Indicator. New 8-page illustrated bulletin gives features, description, typical installation, specifications and principle of operation of maker's "Telstor" continuous level indicator for liquids, granular solids, viscous fluids, and powders.—Fielden Div., Robertshaw-Fulton Controls Co., 2920 North 4 St., Phila., Pa.

Circle **660** on inquiry card.

Liquid-level Control. New 36-page illustrated bulletin "Instrumentation for Liquid Level Control" gives principles of maker's automatic level relays, descriptions, applications, and parts of maker's liquid-level control instruments. Includes discussion of several unit operations.—Techniflex Corp., 55 Jersey Ave., Port Jervis, N.Y.

Circle **661** on inquiry card.

Convex Scale Gages. New 1-page Bulletin 207 presents construction features of maker's convex-scale level gages for 180-degree visibility on "Truscale" gages.—Jerguson Gage & Valve Co., 80 Fellsway, Somerville, Mass.

Circle **662** on inquiry card.

Level Limit Switch. New 4-page Bulletin 1100 describes and illustrates maker's liquid level limit switch.—Revere Corp. of America, Wallingford, Conn.

Circle **663** on inquiry card.

Welding Pad Level Gages. New 2-page illustrated bulletin gives description, design, and uses of maker's welding pad liquid-level gages of reflex and transparent type that are welded directly to tank.—Jerguson Gage Valve Co., 80 Fellsway, Somerville, Mass.

Circle **664** on inquiry card.

RADIOACTIVITY

Radiological Electrometer. New 4-page illustrated Bulletin 110 gives principles, application, accessories and features of distributor's radiological electrometer "Baldwin Type R B" for use with small ionization chambers to measure X and gamma radiation.—Atomic Center for Instruments and Equipment, Inc., 489 Fifth Ave., New York, N. Y.

Circle **665** on inquiry card.

Gamma Radiography. New 10-page illustrated Catalog "Equipment and Sources for Gamma Radiography in Industry" describes maker's directional exposure shield, panoramic exposure shield, encapsulated sources, filmbadge services, etc.—Technical Operations, Inc., 6 Schouler Ct., Arlington, Mass.

Circle **666** on inquiry card.

Pulse Height Analyzer. New 4-page illustrated bulletin gives features and specifications of maker's "Model 115" single-channel pulse-height Analyzer and "Model 418 Oak Ridge A-1" linear amplifier.—Radiation Instrument Development Lab., 2337 W. 67 St., Chicago, Ill.

Circle **667** on inquiry card.

Nuclear Timer. New 2-page illustrated Catalog 5006-7 gives features, wiring diagrams, and specifications for maker's "Model 2-D" timer for shelf, wall, or panel mounting.—Liebel Flarsheim Co., Cincinnati 15, Ohio.

Circle **668** on inquiry card.

Portable Radiation Monitor. New 4-page illustrated bulletin presents purpose, range, features, applications, and specifications of maker's "Radector" wide-range multi-purpose radiation monitor.—Jordan Electronic Sales, Inc., 119 E. Union St., Pasadena, Calif.

Circle **669** on inquiry card.

ANALYTICAL

Mass Spectrometers. New 12-page illustrated bulletin CEC-1200-27 presents articles on mass-spectrometer operation, leak-detector operation, data-processing systems, computer division activities, "Type 1-117" vibration meter, and others.—Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.

Circle **670** on inquiry card.

Magnetic Oxygen Analyzer. New 8-page Bulletin ND46-91(3) describes paramagnetic principle, its application in O_2 measurement, and results with maker's "Speedomax" recorder. —Leeds & Northrup Co., 4934 Stenton Ave., Phila., Pa.

Circle **671** on inquiry card.

Dielectric-constant Chemical Analyzer. New 2-page Bulletin GEA-6057 lists application, features, description, operation, and specifications of maker's new dielectric-constant chemical analyzer for laboratory or process analysis of liquids.—General Electric, Schenectady 5, N. Y.

Circle **672** on inquiry card.

Recording Turbidimeter. New 4-page illustrated Bulletin GEC-1203 presents features, principle of operation, description, application, and specifications of maker's recording turbidimeter for automatically measuring and recording suspended particles in liquid.—General Electric, Schenectady 5, N. Y.

Circle **673** on inquiry card.

Thermal Conductivity Units. New 4-page illustrated Bulletin TC-953 describes maker's thermal-conductivity units for gas analysis, and lists specifications, accessories, applications, and deflection values.—Gow-Mac Instrument Co., 100 Kings Rd., Madison, N. J.

Circle **674** on inquiry card.

Electrolytic Conductivity. New 4-page illustrated Bulletin 6639D gives description, features, specifications and mounting data for maker's "Type RI" electrolytic conductivity indicator-controller.—Industrial Instruments Inc., 89 Commerce Rd., Cedar Grove, N. J.

Circle **675** on inquiry card.

Solution Concentration Meter. New 2-page illustrated Bulletin gives features and description of maker's "Solubridge" instrument for measuring concentration of solutions by conductivity methods.—Industrial Instruments, Inc., 89 Commerce Rd., Cedar Grove, N. J.

Circle **676** on inquiry card.

LABORATORY APPARATUS

Laboratory Apparatus. New 32-page, fall issue of "Scientific Apparatus & Methods" No. 16, features a paper on the technique of amperometric titration utilizing the Sargent Ampot, synchronous rotator, microburette, half cells and micro-electrodes. Also described and illustrated are: centrifuges, electrophoretic papers, spectrophotometers, magnifiers and other chemical laboratory equipment.—Adv. Dept., E. H. Sargent & Co., 4647 W. Foster Ave., Chicago, Ill.

Circle **677** on inquiry card.

Lab Apparatus. New 32-page illustrated issue No. 78 of "Cenco News Chats" features article on use of portable gas-testing absorber for measuring natural-gasoline content of natural gas. Other articles are on vis-

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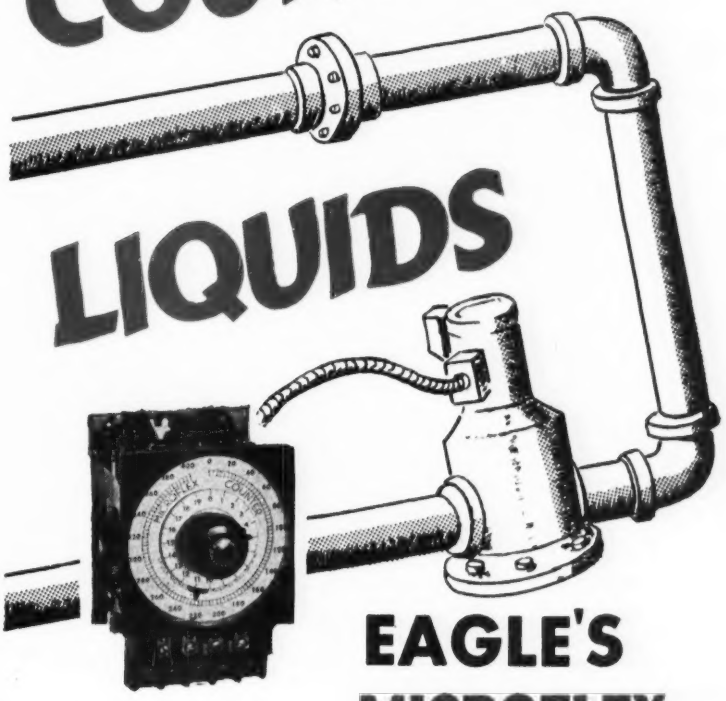

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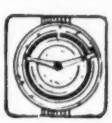

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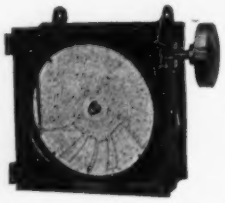

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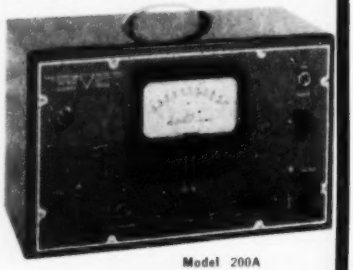

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Chemical Analysis. New 32-page illustrated issue of "Chemist Analyst" (Vol. 42, No. 3) presents reviews, articles, laboratory suggestions and notes of interest to chemical users.—J. T. Baker Chemical Co., Phillipsburg, N. J.

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Clinical pH Meter. New 4-page bulletin describes and illustrates maker's "Model 125B" clinical pH meter for blood pH tests.—Photovolt Corp., 95 Madison Ave., New York, N. Y.

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Colorscope. New leaflet describes and illustrates maker's "Hydrion" colorscope that fits in pocket and facilitates color comparisons of pH test papers.—R. P. Cargille Laboratories, Inc., 117 Liberty St., New York, N. Y.

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Thermobalance Apparatus. New 14-page brochure presents principles, description, features, and operation of Chevenard thermobalance machines, apparatus, and instruments for automatically plotting weight vs. time of pyrolytic experiments in metals, ceramics, glass, chemicals.—R. Y. Ferner Co., Inc., Malden 48, Mass.

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Lab Hot Plate. New leaflet describes and illustrates maker's "Model 2500" seven-inch-round laboratory hot plate.—Thermo Electric Mfg. Co., Dubuque, Iowa.

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Petroleum Testing Apparatus. New 7-page illustrated Bulletin 100-A lists features of maker's petroleum testing apparatus such as oil oxidation apparatus, grease pressure viscometer, evaporation loss of lubricants apparatus, etc.—Technical Equipment Co., 743 Dwight Way, Berkeley, Calif.

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Lab Stirrer. New 1-page Bulletin 480 describes maker's "Universal" variable-speed stirrer.—Eberbach Corp., Ann Arbor, Mich.

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Scientific, Industrial Instruments. New 4-page and 10-page bulletins give facilities, experience, services and description of instruments developed by European firm which has just established U. S. representation.—TOBI, Drs. Jan Boeke, Consulting Engineer, 7908 Pine Rd., Phila., Pa.

Circle **686** on inquiry card.

Electric Desalter. New 1-page illustrated Brochure B gives use, principle of operation, and specifications of maker's electric desalter for removal of inorganic salts from organic and amino acids.—Research Equipment Corp., 1135 Third St., Oakland, Calif.

Circle **687** on inquiry card.

MICROSCOPES

Electron Microscope. New 8-page illustrated bulletin lists features and applications of maker's "EM-100" electron microscope.—North American Philips Co., Inc., 750 S. Fulton Ave., Mt. Vernon, N. Y.

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Electron Microscope. New 12-page illustrated Bulletin 2J6851 RE gives features, applications, results, principle, optical arrangement, penetrating power, applications, and specifications of maker's table-model "Type EMT" electron microscope.—Engineering Products Dept., RCA Victor Div., Camden 2, N. J.

Circle **689** on inquiry card.

Flying Spot Microscope. New 2-page bulletin describes and illustrates combination microscope and flying spot scanner for converting 2-dimensional density distribution into voltages suitable for transmission, with resolution up to 100,000 lines per inch. Includes illustration and description of dosimeter "Type 5 R".—Marconi Instruments Ltd., 23 Beaver St., New York, N. Y.

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OPTICAL

Precision Mirrors. New 20-page illustrated booklet presents methods of producing various types of precision mirrors using silver, aluminum, lead, gold, chromium, platinum, etc. Includes care and maintenance.—Pancro Mirrors, Inc., 2958 Los Feliz Blvd., Los Angeles, Calif.

Circle **691** on inquiry card.

Pocket Stereoscope. New 2-page illustrated bulletin describes and gives directions for use of importer's pocket stereoscope.—Carl Zeiss Inc., 485 Fifth Ave., New York, N. Y.

Circle **692** on inquiry card.

Cameras, Accessories. New price list 44 and 45 covers prices of importer's cameras and accessories, including Contax cameras, lenses, etc.—Carl Zeiss, Inc., 485 Fifth Ave., New York, N. Y.

Circle **693** on inquiry card.

Optical Quartz. New 4-page illustrated issue 16 of "Newsletter" presents articles on use of orifices in manufacture of rayon and rockets, explosion-proof germicidal lamps, small high-temperature electric furnaces, and optical-quality fused quartz.—Engelhard Industries, 113 Astor St., Newark, N. J.

Circle **694** on inquiry card.

Paint and Color Instruments. Five new Bulletins (132, 138, 144, 145, 146) present description and features of maker's reflectometer, paint conditioner, color-difference meter, liquid color standards, and weight-per-gallon cups.—Gardner Laboratory, Inc., Bethesda 14, Md.

Circle **695** on inquiry card.

Illumination Meter. New 4-page illustrated bulletin gives description, features, applications and specifications of maker's "Spectra Brightness Spot Meter" for measuring small spots from a distance.—Photo Research Corp., 127 W. Alameda Ave., Burbank, Calif.

Circle **696** on inquiry card.

Vertical Art Projector. New 4-page illustrated Bulletin gives features and applications of maker's "Model 44 Art-O-Graph" vertical art projector for layout and inspection.—J. A. Engel, Inc., 624 Syndicate Bldg., Minneapolis, Minn.

Circle **697** on inquiry card.

MOISTURE

Dewpoint Recorder. New 2-page illustrated bulletin describes and gives principle of operation of maker's new dewpoint recorder.—Illinois Testing Labs, Inc., 420 N. LaSalle St., Chicago, Ill.

Circle **698** on inquiry card.

Moisture Meter. New 2-page illustrated brochure presents features of English-made "Kappa" electronic moisture meter.—Marconi Instruments, Ltd., 23 Beaver St., New York, N. Y.

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Humidity Control. New 4-page illustrated bulletin gives applications of humidity conditioning to packaging materials and to foundry cupola.—Surface Combustion Corp., Toledo, Ohio.

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STRESS

Stress Analysis Systems. New 24-page illustrated Catalog describes maker's line of industrial instruments including oscillographs, galvanometers, bridge control units, and Bulletin 3040 analyzing of characteristics and technical specifications of maker's vibration and stress analysis system.—Century Geophysical Corp., 1333 N. Utica, Tulsa, Okla.

Circle **701** on inquiry card.

Bridge Balance Unit. New 4-page illustrated Bulletin 105 gives features, specifications, standard and accessory equipment and description of maker's new "Model 82-6" bridge balance and strain indicator unit.—Heiland Research Corp., 130 E. Fifth Ave., Denver, Colo.

Circle **702** on inquiry card.

Photoelastic Stress Analysis. New 12-page illustrated bulletin gives description and specifications of maker's photoelastic model-making kits for stress analysis, straining frames, and polariscopes.—Chapman Labs., P. O. Box 207, West Chester Pa.

Circle **703** on inquiry card.

GAGING, INSPECTION

Ultrasonic Thickness Gages. New 4-page bulletin describes and illustrates maker's "Audigage" and "Vidigage" ultrasonic-resonance thickness gages for measuring thickness from

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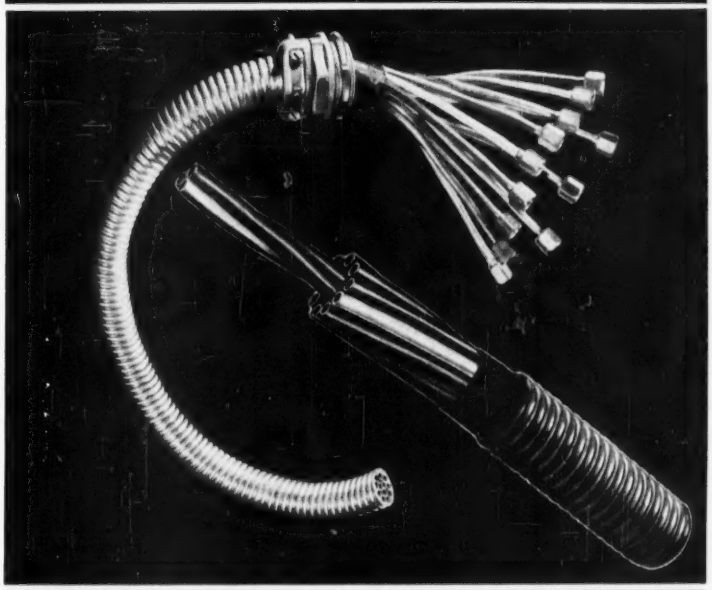

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MANUFACTURERS' NEW LITERATURE

one side.—Branson Instruments, Inc., 430 Fairfield Ave., Stamford, Conn.
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Ultrasonic Test Equipment. New 8-page illustrated Bulletin 50-110 describes maker's ultrasonic "Reflectoscope" testing devices for non-destructive tests on surfaces and under water.—Sperry Products, Inc., Danbury, Conn.
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Depth, Groove Gage. New 4-page Bulletin 53 B describes and illustrates maker's adjustable depth and groove location gage.—Reliant Industries, 4947 Firestone Blvd., South Gate, Calif.
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Dial Gages. New 4-page catalog describes distributor's line of dial, cylinder bore, comparator and bench gages and accessories.—DeWitt Equipment Co., 136 Lafayette St., New York, N. Y.
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TESTING

Universal Testing Machine. New 8-page Bulletin 4206 describes and illustrates maker's "SR-4" universal testing machine.—Baldwin-Lima-Hamilton Corp., Phila. 42, Pa.
Circle **708** on inquiry card.

Dynamic Fatigue Machines. New 10-page illustrated bulletin gives purpose, construction, capacities, and uses of distributor's "Schenck Universal Dynamic Fatigue Machines."—R. Y. Ferner Co., Inc., 110 Pleasant St., Malden, Mass.
Circle **709** on inquiry card.

Magnetic Testing Devices. New 8-page illustrated Bulletin 10 gives features, applications, and description of maker's equipment for magnetic multi-method non-destructive testing of ferromagnetic bars, wire rods, and tubing.—Magnetic Analysis Corp., 511 Fifth Ave., New York, N. Y.
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Portable X-ray Units. New 8-page illustrated bulletin gives features, accessories, and specifications for distributor's portable X-ray units for industrial radiography.—Holger Andreasen, Inc., 703 Market St., San Francisco, Calif.
Circle **711** on inquiry card.

Hardness Tester. New 20-page illustrated brochure gives features, applications, operational principles, accessories, functions, and charts for maker's "Dwarf Brinell Precision Hardness Tester."—R. Y. Ferner Co., Inc., 110 Pleasant St., Malden, Mass.
Circle **712** on inquiry card.

Tensile Tester. New 4-page illustrated Bulletin gives design principles, features, and mechanism of maker's electronic "Model TT-B Tensile Tester."—Instron Engineering Corp., 2 Hancock St., Quincy, Mass.
Circle **713** on inquiry card.

RECORDING

X, Y Recorder. New 4-page Bulletin 5 M presents features and operation of maker's "Autograf" X, Y recorder. Includes typical set-ups for plotting diode characteristics, transistor characteristics, valve characteristics, computer output, etc.—F. L. Moseley Co., 409 N. Fair Oaks Ave., Pasadena 3, Calif.
Circle **714** on inquiry card.

X, Y Recorder. New 4-page illustrated Bulletin presents physical description, functional specifications, and accessories of maker's new X-Y plotter and recorder.—Librascope, Inc., 1607 Flower St., Glendale, Calif.
Circle **715** on inquiry card.

Function Plotter, Generator. New 4-page brochure presents features, operation, and specifications of new "Model T1" curve follower that follows any pencilled curve to generate functions.—Goodyear Aircraft Corp., Akron 15, Ohio.
Circle **716** on inquiry card.

Electronic Recorder. New 6-page folder describes and illustrates maker's "Speedomax" recorder, "Rayotube" pyrometer, and "Homocarb" furnace.—Leeds & Northrup, 4907 Stenton Ave., Phila. 44, Pa.
Circle **717** on inquiry card.

Electronic Recorder. New 8-page illustrated Bulletin F-103 gives features, operation, types, specifications and dimensions of maker's "Tektolog" electronic recorder.—Fielden Instrument Div., 2920 N. 4th St., Phila., Pa.
Circle **718** on inquiry card.

Computer Recorder. New 4-page illustrated bulletin gives features and specifications of maker's "R5 Geda" 6-channel analog recorder for recording solutions to differential equations in either curvilinear or rectangular coordinates.—Goodyear Aircraft Corp., Akron 15, Ohio.
Circle **719** on inquiry card.

Numerical Analog-data Printer. New 6-page bulletin lists features, applications, and accessories of maker's "Ametron" numerical analog-data printer.—Streeter-Amet Co., 4101 Ravenswood Ave., Chicago, Ill.
Circle **720** on inquiry card.

Oscillograph. New 4-page illustrated Bulletin 1-M lists physical data, engineering data, features, outline dimensions, and description of maker's "Model 557" 14-channel oscillograph.—Midwestern Geophysical Laboratory, 3401 S. Harvard, Tulsa, Okla.
Circle **721** on inquiry card.

Recording Oscillographs, Galvanometers. New 24-page brochure contains several bulletins covering maker's "Models 408 and 409" oscillographs, "Model 210" galvanometers, bridge control units, and stress and vibration analysis systems.—Century Geophysical Corp., 1333 N. Utica, Tulsa, Okla.
Circle **722** on inquiry card.

Mobile Oscillograph Control. New 2-page bulletin presents description, specifications, and operation of "Omni" mobile oscillograph control unit, distributed by—Midwestern Geophysical Laboratory, 3401 S. Harvard Ave., Tulsa, Okla.

Circle **723** on inquiry card.

Magnetic Recording Equipment. New 4-page bulletin describes maker's line of multi-channel tape recorders, recorder-reproducers, playback units, and magnetic drum recorder-reproducers.—Brush Electronics Co., 3405 Perkins Ave., Cleveland, Ohio.

Circle **724** on inquiry card.

Carrier-type Recorder. New 8-page Bulletin DS-3-1-2 presents features, application, description, accessories, and performance characteristics of maker's "Model 306" carrier-type recorder with response from d.c. to 5000 cps.—Ampex Corp., 934 Charter St., Redwood City, Calif.

Circle **725** on inquiry card.

Flight Recorder. New 4-page illustrated Bulletin 103 gives features, specifications, and typical records from maker's "Ryan Flight Recorder."—General Mills, Inc., 1620 Central Ave., N.E., Minneapolis, Minn.

Circle **726** on inquiry card.

ACCELERATION, VIBRATION

Accelerometer. New 4-page illustrated Bulletin gives description, general, electrical and mechanical characteristics, and packaging details of maker's "Type TR 145 Accelerometer Transducer."—Servomechanisms, Inc., 316 Washington St., El Segundo, Calif.

Circle **727** on inquiry card.

Accelerometers. Two new 2-page illustrated Bulletins A105 and A314 list characteristics of maker's accelerometers.—Gulton Mfg. Corp., Metuchen, N. J.

Circle **728** on inquiry card.

Vibration Relay. New 2-page illustrated Bulletin GEC-1204 gives application, description, specifications, and vibration analysis chart for maker's vibration relay for protecting rotating equipment from damage due to excessive vibration.—General Electric, Schenectady 5, N. Y.

Circle **729** on inquiry card.

Vibration, Shock Tests. New 4-page illustrated brochure describes services, facilities, and personnel of engineering company, specializing in vibration and shock measurement, mechanical testing, instrument calibration, and research and development.—Vibra-Shock Corp., 6114 River Rd., Washington, D. C.

Circle **730** on inquiry card.

SURFACE, POROSITY

Surface Roughness. New 4-page illustrated Bulletin LT 85 presents reasons for disagreement on degrees of surface roughness and methods of determining roughness.—Micrometri-

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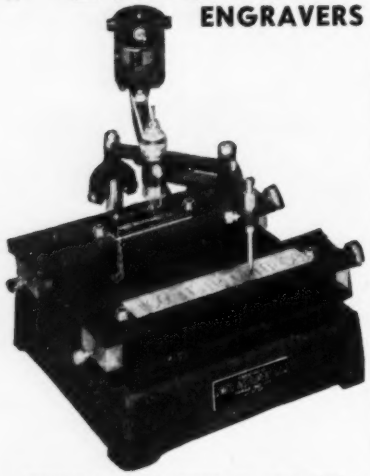

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NEW LITERATURE

cal Mfg. Co., 345 S. Main St., Ann Arbor, Mich.

Circle **731** on inquiry card.

Surface-roughness Indicator. New 4-page illustrated Bulletin ED-21702 gives principle of operation, features, and specifications of maker's new "Surfindicator" surface-roughness gage.—Brush Electronics Co., 3405 Perkins Ave., Cleveland, Ohio.

Circle **732** on inquiry card.

Porosity Detector. New 6-page illustrated Bulletin 353 describes and gives operating procedure of maker's "Type PR" porosity detector for dielectric sheet material.—Viking Instruments, Inc., East Haddam, Conn.

Circle **733** on inquiry card.

Smoothness, Porosity Tester. New 4-page bulletin describes and illustrates maker's smoothness and porosity tester for determination of smoothness of paper.—R. Fuess Inc., 39 West 60 St., New York, N. Y.

Circle **734** on inquiry card.

Surface-roughness Tracer. New 1-page bulletin gives features, specifications, and applications of maker's "LE-type" tracers designed for surface-roughness measurements in small, deep holes.—Micrometrical Mfg. Co., 345 S. Main St., Ann Arbor, Mich.

Circle **735** on inquiry card.

TEST CHAMBERS

Test Cabinets. New 4-page illustrated Bulletin S-950-2 describes maker's standard line of research and test units. Includes temperature-conversion table.—Bowser Technical Refrigeration, Terryville, Conn.

Circle **736** on inquiry card.

Environmental Test Equipment. New 4-page Bulletin 3M 553 describes and illustrates maker's altitude, temperature, and humidity test chambers.—American Research Corp., Bristol, Conn.

Circle **737** on inquiry card.

SPEED

Speed Control Devices. New 20-page illustrated catalog describes maker's line of speed control devices, such as variable speed servo units. Also describes load-compensated variable-speed drive system for small motors.—Servospeed Div., Electro Devices, Inc., 4 Godwin Ave., Paterson, N. J.

Circle **738** on inquiry card.

Mach Computer. New 4-page illustrated bulletin gives features, drawings, operation, characteristics, and typical applications of maker's new mach computer for determining mach number.—Servomechanisms, Inc., 316 Washington St., El Segundo, Calif.

Circle **739** on inquiry card.

Electric Tachometers. New 4-page illustrated Bulletin 9-53 presents description, features, and operating principle of maker's electric tachometer.—Madison Electric Products, Inc., Madison, Ohio.

Circle **740** on inquiry card.

COUNTING, COMPUTING

Counters, Timers, Data Handling. New 56-page illustrated catalog gives description, features, and specifications for maker's counters, scalers, timers, electronic digital computers, memory devices, etc. Also includes articles on development, applications and operating principles of counters and 4-tube counter decade.—Potter Instrument Co., Inc., Great Neck, N. Y.

Circle **741** on inquiry card.

Timers, Counters. New 12-page illustrated Bulletin 350 gives features, application, and engineering data of maker's single-interval, single-interval-reset, multiple-interval-reset, and repeat-cycle timers and reset counters.—Eagle Signal Corp., Moline, Ill.

Circle **742** on inquiry card.

Integrator. New 4-page Bulletin gives description, principle of operation and specifications of maker's electromechanical integrator for integrating any input electrical signal.—Instron Engineering Corp., Quincy 71, Mass.

Circle **743** on inquiry card.

Complex Plane Analyzer. New 6-page illustrated bulletin describes and presents theory and operation, specifications and features of maker's "Type 250-A" complex plane analyzer, a computer for network analysis and control system design.—Technology Instrument Corp., Main St., Acton, Mass.

Circle **744** on inquiry card.

Analog Computing Devices. New 8-page illustrated catalog presents origin and development, applicability, quantitative data and accuracy, customer services, and devices of maker for electronic analog computation.—George A. Philbrick Researchers, Inc., 230 Congress St., Boston 10, Mass.

Circle **745** on inquiry card.

Data Reduction, Read-out. New 6-page folder describes and illustrates maker's digital read-out machine, electrical input keyboard, digital converter, etc.—Clary Multiplier Corp., San Gabriel, Calif.

Circle **746** on inquiry card.

Counter Decade. New 2-page bulletin describes and illustrates maker's "Model 1104" plug-in counter decade; new 2-page bulletin covers "Model 1112" power-supply regulator.—Clary Multiplier Corp., San Gabriel, Calif.

Circle **747** on inquiry card.

Automatic Counter-Marker. New 1-page bulletin describes maker's automatic "Mark-N-Count" marking and counting device.—May Engineering Co., 6055 Lankershim Blvd., N. Hollywood, Calif.

Circle **748** on inquiry card.

POSITIONING

Magnetic Clutch, Positioning Movement. New 2-page Bulletin DL-C 311 describes and illustrates maker's magnetic-fluid-clutch metering/positioning movement.—Texas Instruments Inc., 6000 Lemmon Ave., Dallas, Texas.

Circle **749** on inquiry card.

Linear-position Transducer. New 2-page illustrated bulletin presents features, operation, typical circuit schematic, and specifications for maker's "Model LP-1" variable-reluctance-type linear-position transducer.—North American Instruments, Inc., 2420 N. Lake Ave., Altadena, Calif.

Circle **750** on inquiry card.

VTVM's

VTVM. New 4-page Bulletin R-1-A describes and illustrates maker's "Model R-1" lab-quality voltmeter featuring low-drift characteristics and 65 combinations of ranges and modes for d-c., a-c., and resistance measurements.—Southwestern Industrial Electronics Co., Inc., 2831 Post Oak Rd., Houston, Texas.

Circle **751** on inquiry card.

VTVM. New 1-page Bulletin describes maker's new "Model 273" high-impedance battery-operated self-contained vacuum-tube d-c. voltmeter.—Associated Research, Inc., 3758 W. Belmont Ave., Chicago, Ill.

Circle **752** on inquiry card.

OSCILLOSCOPES

Cathode-ray Oscillography. New 20-page Vol. 14, No. 2 issue of "Oscillographer" is devoted to developments, applications, and techniques in cathode-ray oscillography, including techniques in pulse measurement.—Allen B. DuMont Labs, Inc., 760 Bloomfield Ave., Clifton, N. J.

Circle **753** on inquiry card.

Cathode-ray Oscillograph. New 6-page illustrated Bulletin 301-A describes maker's miniaturized wide-band, quantitative cathode-ray oscillograph, including special features and specifications.—Allen B. DuMont Laboratories, Inc., 760 Bloomfield Ave., Clifton, N. J.

Circle **754** on inquiry card.

Oscillosynchroscope. Two new 6-page illustrated Bulletins describe and present functional diagram, control arrangement, sample wave pulses, electrical and mechanical features of maker's "Model OL-23 and OL-16" oscillosynchroscopes.—Browning Laboratories, Inc., Winchester, Mass.

Circle **755** on inquiry card.

Cathode-ray Oscilloscope. New 1-page bulletin describes and gives technical specifications of maker's 5-in. cathode-ray oscilloscope for electronic service work.—Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio.

Circle **756** on inquiry card.

Cathode-ray Oscilloscope. New 4-page bulletin describes and illustrates maker's "Type 535" dual-trace cath-

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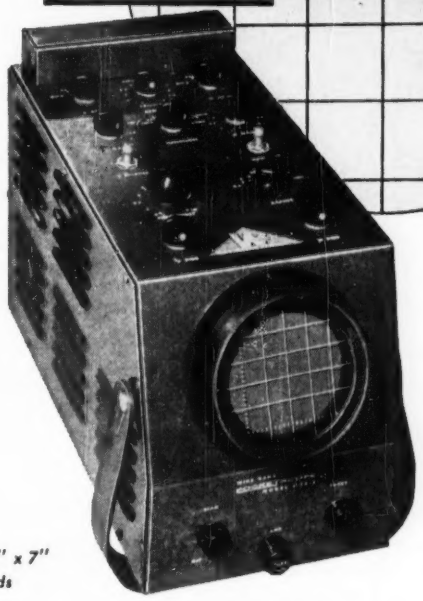

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The WIDE BAND POCKETSCOPE, model S-14-B, hits a new high in frequency response for light, compact, truly portable oscilloscopes. The response extends all the way from DC to 700 KC within —2 db without peaking. Thus providing a pulse rise time of 1.8 microseconds. Furthermore, sensitivity has not been unduly compromised in order to accomplish such fidelity. The vertical sensitivity is 50 millivolts rms/inch. The sweep is operated in either a repetitive or trigger mode and covers a range from 0.5 cycles to 50 KC with synchronization polarity optional. Other essential vertical and horizontal amplifier characteristics include non-frequency discriminating attenuators and gain controls as well as individual calibration voltages. Additional provisions for direct access to all the deflection plates, the second anode, and the amplifier outputs help to make the S-14-B a standout instrument of flexibility and utility. All this plus portability! The incredibly small size and light weight of the S-14-B now permits "on-the-spot" use of the oscilloscope in all industrial, medical, and communications fields. Its rugged construction assures "laboratory performance" regardless of environment.

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Also RAYONIC® Cathode Ray Tubes and Other Associated Equipment

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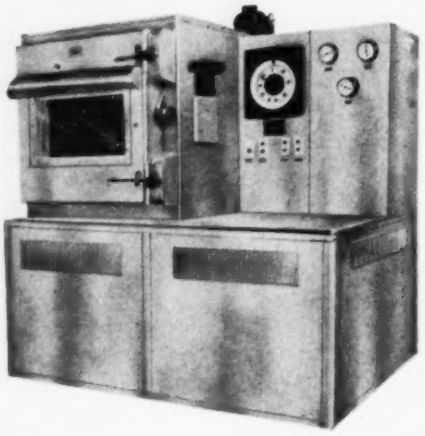
TEST CHAMBERS



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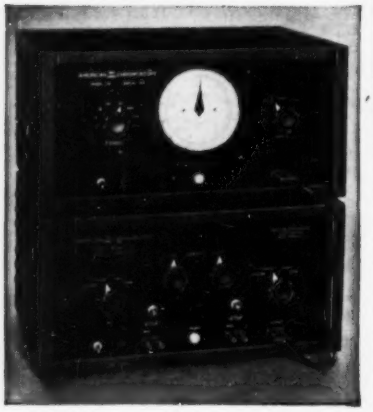
From 10 Microseconds to 3 Seconds



The time interval between any two components in electrical, mechanical or electro-mechanical systems can now be measured, simply and accurately, with Model 110 American Chronoscope and Model 211 Input Adapter.

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AMERICAN CHRONOSCOPE CORPORATION

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For more information circle **203** on inquiry card.

NEW LITERATURE

ode-ray oscilloscope. Includes characteristics, illustrations of various operations, and descriptions of maker's plug-in vertical preamplifiers.—Tektronix Inc., Portland, Oregon.

Circle **757** on inquiry card.

SIGNAL GENERATORS

Unit Oscillator. New 8-page illustrated issue Vol. 28, No. 4 of "Experimenter" describes and lists features and specifications of maker's "Type 1211-A" unit oscillator, plus index of Volumes 26 and 27.—General Radio Co., Cambridge, Mass.

Circle **758** on inquiry card.

Microwave Oscillator. New 1-page bulletin describes and illustrates maker's "Model 803" ultra-stable microwave oscillator.—Laboratory for Electronics Inc., 75 Pitts St., Boston, Mass.

Circle **759** on inquiry card.

Signal Generators. New 26-page catalog describes and illustrates maker's signal generators, UHF sweep generators, panoramic adapter, and accessories.—New London Instrument Co., Box 189, New London, Conn.

Circle **760** on inquiry card.

POWER SUPPLIES

Millivolt Source. New 2-page bulletin gives description and specifications of maker's "Model MV-60" millivolt source for instrument calibration.—Allegany Instrument Co., 1000 Oldtown Rd., Cumberland, Md.

Circle **761** on inquiry card.

Power Supplies. New 4-page illustrated Bulletin 35514 gives features, design, electrical, and mechanical features of maker's "TVN-11" Klystron power supply.—Browning Labs., Inc., Winchester, Mass.

Circle **762** on inquiry card.

Power Supplies. New 32-page illustrated Catalog 4 describes and lists features and specifications of maker's power supplies for low, high, and ultra-high voltage and electronic instruments. Includes schematics of high-voltage circuits.—Beta Electric Corp., 333 E. 103 St., New York, N. Y.

Circle **763** on inquiry card.

Dynamotors, Aircraft Instruments. New 20-page illustrated Catalog 27 gives description of distributor's large line of aircraft instruments, hydraulic equipment, dynamotors, relays, capacitors, switches, etc.—Electro Devices Inc., 4 Godwin Ave., Paterson, N. J.

Circle **764** on inquiry card.

Regulated Power Supplies. New 4-page bulletin describes and illustrates maker's absolute d-c. power supplies with 0.01% stability and regulation. —Kalbfell Laboratories Inc., 1090 Morena Blvd., San Diego, Calif.

Circle **765** on inquiry card.

DC to AC Converters. New 20-page Catalog 553 describes and illustrates maker's d-c. to a-c. converters and

inductor alternators.—Carter Motor Co., 2644 N. Maplewood Ave., Chicago, Ill.

Circle **766** on inquiry card.

Plug-in Heater Rectifier. New 1-page illustrated bulletin gives description, application, and specifications of maker's "B3001" plug-in heater rectifier for supplying d-c. heater current to low-level amplifier stages.—Vector Electronic Co., 3352 San Fernando Rd., Los Angeles, Calif.

Circle **767** on inquiry card.

Adjustable Voltage Reference. New 2-page illustrated bulletin gives features and specifications for maker's adjustable voltage reference "Model PM-300," a secondary standard cell. —General Precision Laboratory, Inc., Pleasantville, N. Y.

Circle **768** on inquiry card.

AMPLIFIERS

Amplifier. New 4-page illustrated brochure presents new "Type GA-IR" high-gain a-c. (5 to 10,000 cps.) amplifier for use with maker's recording oscillograph. Includes diagrams, frequency response, and linearity.—Midwestern Geophysical Laboratory, 3401 S. Harvard Ave., Tulsa, Okla.

Circle **769** on inquiry card.

Carrier Amplifier. New 9-page Bulletin 107 gives features, specifications, standard and accessory equipment, and description of components of maker's new "Model 119" amplifier system for oscillograph recording.—Heiland Research Corp., 130 E. Fifth Ave., Denver, Colo.

Circle **770** on inquiry card.

Carrier Amplifier. New 2-page illustrated Bulletin D, No. 2 describes and gives specifications of maker's new "Model 8110 Universal Carrier Amplifier."—Edin Co., Inc., 207 Main St., Worcester, Mass.

Circle **771** on inquiry card.

Synchronous Chopper. New 1-page bulletin describes and gives drawings of maker's instrument-type DC-AC synchronous chopper.—Instrument Development Laboratories, Inc., 163 Highland Ave., Needham Heights, Mass.

Circle **772** on inquiry card.

Linear, Integrating Amplifier. New 4-page illustrated Bulletin A-6 gives general description, frequency response, sensitivity, and accessory equipment for maker's "Type A-6" high-gain linear or integrating amplifier for use with oscillographs.—William Miller Instruments, Inc., 325 N. Halstead Ave., Pasadena, Calif.

Circle **773** on inquiry card.

IF Amplifier. New 4-page Bulletin 207 E1 describes and illustrates maker's new "Model 207E1" tandem 40-Mc. i-f. amplifier.—Tube Dept., RCA, Harrison, N. J.

Circle **774** on inquiry card.

INSTRUMENTS ELECTRICAL TEST

Electrical Testing Instruments. New 16-page illustrated Bulletin GEA-

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BOMBING RUN IN THE LABORATORY

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On the analog computer, this engineer has duplicated flight conditions for a new jet plane making a bombing run on automatic pilot. Then he checks the performance of the system as charted by the six-channel Brush Oscillograph. Mission accomplished!

In many such exacting studies, immediate recording of electrical or mechanical phenomena by Brush Oscillographs saves engineering time and simplifies tests. These precision instruments give you answers in writing—of stress, strain, torque, vibration, pressure and other variables. They are available to suit your needs... from the single channel unit up to the six-channel size shown above.

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QX Checker TYPE 110-A

A production testing instrument with laboratory accuracy under factory conditions

- Rapid and accurate comparison of inductors and capacitors to known standards.
- Sturdy, simple, easily operated by factory personnel.
- Offers quick comparison between supplier and user.

COIL TESTING

Coils are compared to a standard coil and the relative Q of the tested coil is read directly in percentage relation to the standard coil. The dial of the vernier condenser employed indicates the difference in inductance between the standard coil and the coils under test.

CONDENSER TESTING

The difference between capacitance of test condensers and standard condensers is indicated in mmf. by using an accessory coil 112-A22. Condenser losses are indicated on the meter on the instrument.

SPECIFICATIONS

OSCILLATOR FREQUENCY RANGE: 100 kc to 25 mc in six ranges using plug-in accessory inductors.
ACCURACY OF FREQUENCY CALIBRATION: Aproximately ± 3%.
RANGE OF COIL CHECKS: 1 microhenry to 10 millihenries.
ACCURACY OF COIL CHECKS: For Q = 100 or more and L above 10 mh; ± 0.2%.
RANGE OF CONDENSER CHECKS: 2 mmf to 1000 mmf.
INDICATING SYSTEM: Large diameter Q indicating meter with expanded 3½ inch scale. Double range 5 inch vernier condenser scale ± 5 and ± 50 mmf.
VOLTMETER: Stable self-contained Q voltmeter practically independent of normal line voltage fluctuations.
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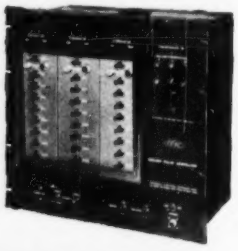
MODEL 300



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New Basic Test Instruments for NUCLEAR, RADAR, TV, UHF, and other fields in which FAST PULSE CIRCUITS are employed. Three or more pulse outputs are available in Model 300.

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RISE TIME: .001 μsec. from 10% to 90% amplitude
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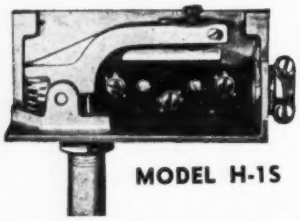
Temperature Limit Controls



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The Burling Model H-1S is approved by Factory Mutual Laboratories as a high temperature safety alarm or cut-out. It is used on ovens, furnaces, dryers, and similar equipment. Snap-action switch may be manual reset type.

Features of Other Burling Controls

- Ranges from −300°F. to +1800°F.
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- Explosion and waterproof housings

Send For Bulletin 101

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South Orange, N. J.

Burling TEMPERATURE Controls

For more information circle **207** on inquiry card.

NEW LITERATURE

5469B provides data on instruments such as hook-on volt-ammeters, wattmeters, power-factor meters, portable recorders, voltmeters, phase-sequence indicators, hand pyrometers, etc.—General Electric, Schenectady 5, N. Y.

Circle **775** on inquiry card.

DC Test Instrument. New 1-page Bulletin 14AA describes and gives uses and specifications of maker's "Model 424 DC Hypot" for testing windings, etc.—Associated Research, Inc., 3758 W. Belmont Ave., Chicago, Ill.

Circle **776** on inquiry card.

Low-resistance Measurement. New 4-page illustrated issue Vol. 9 No. 2 of "Instrument News" presents articles on grounding principles and practices as applied to industrial plants, and on low-resistance measurement problems.—James G. Biddle Co., 1316 Arch St., Phila., Pa.

Circle **777** on inquiry card.

Corona Detector. New 2-page illustrated Bulletin GEC-1202 presents features, description, operation, and specifications of maker's corona detector for high-voltage rotating equipment.—General Electric, Schenectady 5, N. Y.

Circle **778** on inquiry card.

Ionization Test Set. New 1-page Bulletin 66-89 describes maker's ionization test set, uses, and components for detecting transformers, cables, capacitors, etc. for ionization starting voltage at 60 cycles.—James G. Biddle Co., 1316 Arch St., Phila., Pa.

Circle **779** on inquiry card.

Capacity Meter. New 1-page bulletin gives description and applications of maker's "Model C102 Capaciprobe" for measuring capacitance of points in an r-f., pulse, or switching circuit while circuit is operating.—Electronics Production Service Co., 871 Washington St., Canton, Mass.

Circle **780** on inquiry card.

High-current Test Instruments. New 4-page Catalog 953 gives specifications, application data, and prices of 6 models of maker's instruments for testing high-current devices.—Multi-Amp Corp., Harrison, N. J.

Circle **781** on inquiry card.

Electric Test Instruments. New 12-page illustrated Bulletin 19-53 lists and describes maker's electrical testing instruments, ohmmeters, ground testers, ionization test sets, tachometers, etc.—James G. Biddle Co., 1316 Arch St., Philadelphia, Pa.

Circle **782** on inquiry card.

Phase Comparator. New 1-page brochure presents maker's phase comparator, a plug-in full-wave bridge comparator that can be used as modulator, demodulator, or switch.—Sanders Associates, Inc., 137 Canal St., Nashua, N. H.

Circle **783** on inquiry card.

AUDIO, TV

Electronic, Audio Equipment. New 16-page illustrated catalog presents distributor's line of radio, television, electronic, and sound equipment.—Hudson Radio & Television Corp., 48 W. 48 St., New York, N. Y.

Circle **784** on inquiry card.

Audio, TV Equipmert. New 128-page illustrated "Complete Audio Catalog" describes distributor's complete line of home music, public address, recording, broadcast, and special audio equipment. Includes TV chassis.—Terminal Radio Corp., 85 Courtland St., New York, N. Y.

Circle **785** on inquiry card.

Industrial Television. New 8-page illustrated Bulletin 2J8837 describes applications and equipment for supervision of industrial processes by ITV.—Radio Corp. of America, Camden, N. J.

Circle **786** on inquiry card.

Industrial Television. New 4-page illustrated bulletin gives features, descriptions, applications and specifications for maker's new line of industrial television equipment including miniature, portable and underwater cameras, monitors, and power units.—General Precision Laboratory, Inc., Pleasantville, N. Y.

Circle **787** on inquiry card.

Transmission Line Characteristics. New 12-page illustrated issue Vol. 2, No. 10 of "Demodulator" explains complex characteristics of transmission lines and shows why carrier systems take advantage of the characteristics.—Lenkurt Electric Co., San Carlos, Calif.

Circle **788** on inquiry card.

Remote Control Broadcasting. Three new 4-page bulletins give features, operations and description of maker's remote control and metering system for unattended broadcast transmitters.—Hammarlund Mfg. Co., Inc., 460 W. 34 St., New York, N. Y.

Circle **789** on inquiry card.

PANEL INDICATORS

Miniature Panel Instruments. New 2-page Bulletins 112 and 120 describe and give general specifications, tables of standard ranges, and approximate resistances of maker's 1½-in. square or round watertight panel instruments.—DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City, N. Y.

Circle **790** on inquiry card.

Ruggedized Panel Meters. New 4-page illustrated Bulletin 693-137-1 lists features and specifications of maker's line of ruggedized D'Arsonal meters.—Sun Electric Corp., Harlem and Avondale, Chicago, Ill.

Circle **791** on inquiry card.

Illuminated Panel Meters. New 2-page illustrated bulletin gives description, specifications, and mounting dimensions of maker's 1½-inch illuminated panel meters.—International

Automatic Valve Operation With No Electrical Power!

NEW! ASCO®

Pressure Operated Manual Reset Valves

Reduce Hazards!

Provide Reliable Operation!

APPLICATIONS—Bulletin 8035 Valves are ideal for remotely controlled, safety shut-off applications where it is not desirable to depend upon electrical power for operation. Valves are *pressure operated*, thus:

A. eliminating explosive hazards encountered with electrical operation.

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AVAILABILITY—Two types:

(1) Trip on pressure failure

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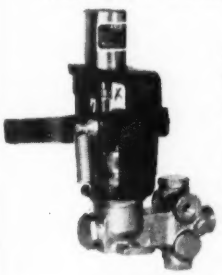
Standard Valves are constructed of bronze, cast-iron, steel, and stainless steel. Other materials are available if required. Valves can be provided with auxiliary switches for indicating lights or electrical control circuits.

MOVEMENT	PIPE SIZES (Inches)	Maximum PRESSURES (lbs./sq. in.)
2 Way*	⅜-6	600
3 Way	¼-½	300
4 Way	¼-¾	250

**Normally open or normally closed*



OPERATION — Valve is manually set and remains in operating position until pressure is lost or applied (depending upon Valve type). Once tripped, the Valve must be manually reset.

ASCO Solenoid VALVES

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ASCO lists hundreds of standard valve types and maintains an engineering service for special designs. We manufacture a complete line of Electromagnetic Controls, including Automatic Transfer Switches, Remote Control Switches, Contactors, Relays, and Complete Control Panels.

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RANGE: 0 to 0.2 Roentgen
ACCURACY: ±15% of true dosage from 0.08 Mev to 2.0 Mev (±10% on Cobalt 60)

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A direct reading pocket dosimeter lets you SEE, at any time, the exact quantity of radiation to which you have been exposed. Plants using industrial radiography or radioactive isotopes, either in the laboratory or in production, should maintain constant check on potential health hazards arising from scattered radiation. A Victoreen direct reading pocket dosimeter, worn like a fountain pen by technician or supervisor, shows at a glance the quantity of radiation in roentgens A charger is required for operation.

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For a large number of employees subject to exposure by stray radiation, use of an indirect reading dosimeter by each individual is more economical, too. All dosimeters used during the day are turned in to one responsible person, who reads each dosimeter and records the data—thus providing a permanent, daily, written record of the dose received by each employee. Management has a true picture of radiation hazard conditions in the plant. A charger-reader is required for operation. Victoreen's quarter century experience in radiation measurement assures the highest quality.

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C-25 motor controller. Input: 110-120 volts A.C. Output: 0.130 volts D.C. for armature circuit and ¼ ampere for field circuit. Will operate 1/50 to ¼ hp shunt would direct current or series wound motors.

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For more information circle **211** on inquiry card.

NEW LITERATURE

Instruments Inc., P. O. Box 2954, New Haven, Conn.

Circle **792** on inquiry card.

SWITCHES, RELAYS

Instrument Keys, Switches. New 12-page illustrated Catalog EU gives design features, mountings, and specifications of maker's line of keys and switches.—Leeds and Northrup Co., 4934 Stenton Ave., Phila., Pa.

Circle **793** on inquiry card.

Sequencing Relays. New 2-page issue of "Relay Highlights No. 3" gives uses and specifications of maker's "Series OCS" relays, adapted from rotary stepping switch, for sequencing, cam switching, stepping, etc.—Automatic Electric Sales Corp., 1033 W. Van Buren St., Chicago, Ill.

Circle **794** on inquiry card.

Switches, Components. New 32-page illustrated Catalog 4018-D gives description and specifications of maker's line of key switches, limit switches, lamps, jacks, caps, plugs, terminals, etc.—Automatic Electric Sales Corp., 1033 W. Van Buren St., Chicago, Ill.

Circle **795** on inquiry card.

Automatic Time Switch. New 8-page illustrated Bulletin GEC-535C describes design, operation, and application of maker's "Type T-27" heavy-duty time switch for automatic control of street lighting, signs, etc.—General Electric, Schenectady 5, N. Y.

Circle **796** on inquiry card.

Snap-action Switch. New 4-page issue of "Micro Tips" (Vol. 1, No. 11) gives many practical applications for maker's precision switches.—Micro Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle **797** on inquiry card.

Overload Relays. New 4-page illustrated Bulletin 5101A gives complete engineering data, model specifications, complete description of hydraulic-magnetic operating principle, graphic explanation, and applications of maker's hydraulic-magnetic "Type C Silic-O-Netic" overload relay.—Heinemann Electric Co., 304 Plum St., Trenton, N. J.

Circle **798** on inquiry card.

Hermetically Sealed DC Solenoids. New 2-page illustrated Bulletin PR-S1 describes maker's hermetically sealed DC solenoid and gives dimensional drawing and armature variations.—Cannon Electric Co., 3209 Humboldt St., Los Angeles, Calif.

Circle **799** on inquiry card.

Snap-action Relay. New 1-page illustrated Bulletin C-1-753 describes and gives dimensions of maker's snap-action plate-circuit relay.—Thermo Instruments Co., 1310 Old County Rd., Belmont, Calif.

Circle **800** on inquiry card.

Rotary Relays. New 4-page Bulletin 3M describes and illustrates maker's miniature rotary relays.—S. H. Couch Company, Inc., North Quincy 71, Mass.
Circle **801** on inquiry card.

TRANSISTORS, TUBES

Transistors. New 24-page illustrated booklet "Transistors Today and Tomorrow" gives basic principles, uses, advantages, experimental applications, possibilities, origin, various types, production process, future opportunities, and simple diagrams explaining transistor principles.—Radio Corp. of America, RCA Bldg., 30, Rockefeller Plaza, New York, N. Y.
Circle **802** on inquiry card.

Transistors. New 4-page illustrated brochure explains problems, development, and research being conducted in field of transistor-application to instruments.—Minneapolis-Honeywell Regulator Co., Industrial Div., Phila. 44, Pa.
Circle **803** on inquiry card.

Junction Transistors. Two new Bulletins (EGC-20 and EGC-21) give specifications, characteristics and operation of maker's junction transistors "Types 2N43 and 2N44" for high and intermediate gain, low to medium power.—General Electric, Syracuse 1, N. Y.
Circle **804** on inquiry card.

Diffused-junction Rectifiers. New 4-page illustrated Brochure ECG-10B presents principles, features, operation, and characteristics of maker's P-N junction rectifiers with close to 100-percent rectification efficiency.—General Electric, Syracuse 1, N. Y.
Circle **805** on inquiry card.

Electron Tubes. Three new 4-page Bulletins (5719, 5814, and 5840) describe and illustrate maker's new "5719" high-mu triode, "5814" medium-mu twin triode, and "5840" sharp-cutoff pentode, respectively.—Tube Dept., RCA, Harrison, N. J.
Circle **806** on inquiry card.

Photosensitive Transistor. New 2-page bulletin describes maker's "Type X-25" NPN junction photosensitive transistor with sufficient power to operate a relay.—Transistor Products, Inc., Snow & Union Sts., Boston, Mass.
Circle **807** on inquiry card.

Germanium Diodes. New 4-page illustrated bulletin gives basic construction, features, and characteristics of maker's germanium diodes.—Semiconductor Sales Dept., Hughes Aircraft Co., Culver City, Calif.
Circle **808** on inquiry card.

Spectrophotometer Photomultiplier. New 1-page Bulletin 331 gives construction, application, and features of maker's "Model B" photomultiplier attachment for greater sensitivity in maker's "Model B" Spectrophotometer—Beckman Instruments, Inc., S. Pasadena, Calif.
Circle **809** on inquiry card.

BOURNS
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Trade Mark

An adjustable . . . Sub-miniature potentiometer for precise circuit trimming

BOURNS TRIMPOT is a wire-wound potentiometer designed for miniaturized equipment. Adjustments of the 25 turn slotted shaft are made with a screw driver.

Accurate electrical settings in increments of ¼ to ½% are easily controlled and are securely retained without the use of lock-nuts.

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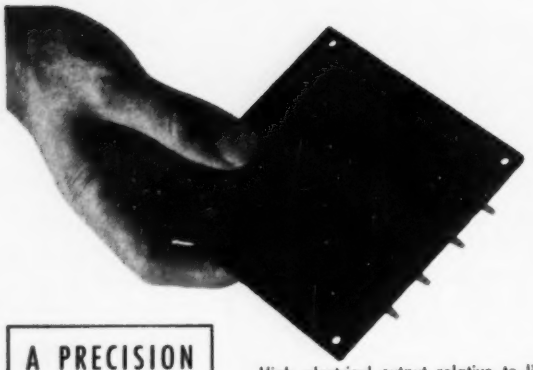

new instrument component

A PRECISION HEAT-FLOW TRANSDUCER

High electrical output relative to linear heat-flow gradient through the new Beckman & Whitley Heat-Flow Transducers permits instrumentation set-ups with directly-driven indicating or recording meters. Individual thermopile sections, containing large area-density of silver-constantan thermocouple junctions on both sides of thin, uniformly heat-conducting slabs, can be connected in various electrical and physical configurations depending on specific application needs.

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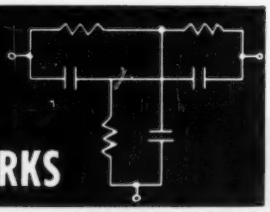

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NEW LITERATURE

RESISTORS, POTENTIOMETERS

Film Potentiometers. New 4-page illustrated brochure gives features, general characteristics, and specifications for maker's film potentiometers with high resolution.—Servomechanisms, Inc., 316 Washington St., El Segundo, Calif.

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Tape Resistor. New 1-page illustrated brochure presents features of maker's tape resistors for printed circuits.—Sanders Associates, Inc., 137 Canal St., Nashua, N. H.

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Precision Potentiometers. New 14-page illustrated Catalog 140-36-56 gives general characteristics, applications, and performance features plus specifications for maker's large line of precision potentiometers.—Fairchild Camera and Instrument Corp., 225 Park Ave., Hicksville, N. Y.

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Precision Potentiometer. New 6-page illustrated Bulletin Series C-200 presents description, features, specifications, and resistance values for maker's external-phasing 2-in. high-precision potentiometers.—DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City, N. Y.

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Stable Carbon Resistors. New 8-page illustrated brochure and 4-page illustrated Engineering Bulletin #1 present features of distributor's high-stability carbon resistors and deposited-carbon resistors. Includes discussion on principles of thermal noise and current noise.—Rockbar Corp., 211 E. 37 St., New York, N. Y.

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ELECTRONIC COMPONENTS

Printed Circuits. New 8-page illustrated bulletin gives uses, materials, processes and characteristics of maker's "Photocircuits" printed circuits and allied electronic assemblies.—Photocircuits Corp., Glen Cove, N. Y.

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Stamped Circuits. New 4-page illustrated bulletin presents general description, electrical characteristics, and applications of maker's stamped circuits.—Sylvania Electric Products Inc., Warren, Pa.

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Electronic Components. New 8-page illustrated catalog presents maker's line of radio and cathode-ray tube sockets, terminal boards and strips, plugs, connectors, and loop antennas.—Sylvania Electric Products, Inc., Warren, Pa.

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Transformers. New 4-page illustrated bulletin describes acomplish-

ments and facilities of company of engineers specializing in transformers, filters, and reactors.—Transformer Engineers, 161 E. California St., Pasadena, Calif.

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Miniature Pulse Transformers. New 1-page bulletin describes and gives engineering characteristics of maker's miniature pulse transformers.—Electronics Production Service Co., 871 Washington St., P. O. Box 268, Canton, Mass.

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Ultrasonic Delay Lines. New 2-page bulletin lists features, specifications, and applications for maker's "Solid" ultrasonic delay lines utilizing fused quartz as delay medium.—Laboratory for Electronics, Inc., 75 Pitts St., Boston, Mass.

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Transducers. New 20-page issue (Vol. 14 No. 1) of "Oscillographer" features articles on "The Function and Design of Transducers for Oscillography," and on "Type 304-A" oscillograph.—Allen B. DuMont Labs., Inc., 760 Bloomfield Ave., Clifton, N. J.

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Electronic Components. New 32-page illustrated catalog presents maker's line of coils and allied components.—J. W. Miller Co., 5917 S. Main St., Los Angeles, Calif.

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Hermetic-seal Terminals. New 6-page illustrated Bulletin 949-A presents maker's line of hermetically sealed terminals.—Electrical Industries, Div. of Amperex Electronic Corp., 44 Summer Ave., Newark, N. J.

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Sealed Power Connectors. New 4-page Bulletin 2E-1 lists features, material data, construction, finish, specifications, and types of maker's "Series 2E" sealed power connectors.—Cannon Electric Co., 3209 Humboldt St., Los Angeles, Calif.

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Ceramic Insulators. New 4-page illustrated catalog presents maker's line of "Alumina" ceramic insulators.—Western Gold & Platinum Works, 589 Bryant St., San Francisco, Calif.

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Terminals, Feedthroughs. New 44-page Catalog 7-1-53 describes and illustrates maker's standardized electronic components, including lugs, ferrules, etc.—U. S. Engineering Co., 521 Comercial St., Glendale, Calif.

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Aircraft Components. New 20-page illustrated Booklet GEA-5972 gives description and application of maker's line of aircraft components, including subminiature capacitors, air turbine drives, ballasts for aircraft flourescent lamps, and exhaust gas thermocouples for jet engines.—General Electric, Apparatus Sales Div., Schenectady 5, N. Y.

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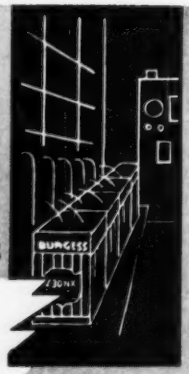

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Autotransformer. New 4-page illustrated Bulletin 76 gives uses, features, and general specifications of maker's "Varistat" 2000-watt variable autotransformer.—Ward Leonard Electric Co., Mount Vernon, N. Y.
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Quartz Crystals. New 20-page illustrated bulletin gives principle of piezoelectric effect, describes manufacture of quartz crystals, and types of crystals manufactured.—Standard Piezo Co., Carlisle, Pa.
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Capacitors. New 4-page Bulletin NB-154 describes and illustrates maker's "Budroc" steatite-cased paper tubular capacitors.—Cornell-Dubilier Electric Corp., South Plainfield, N. J.
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Kinescope Deflection Circuit. New 8-page "Application Note AN—159" discusses maker's new horizontal-deflection and high-voltage circuit for 27-in. kinescopes.—Tube Dept., RCA, Harrison, N. J.
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Electronic Components. New 20-page illustrated Catalog 53-A lists features of maker's line of plugs, jacks, switches, test leads and hardware for electronic applications.—Herman H. Smith, Inc., 2326 Nostrand Ave., Brooklyn, N. Y.
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Connectors, Terminals. New 16-page catalog describes maker's line of connectors, thermocouples, printed-circuit hardware, and terminal boards. Includes applications, specifications, and types available.—Viking Electric, 1061 Ingraham St., Los Angeles 17, Calif.
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Terminal Blocks. New 2-page illustrated Form B1-P2 presents features and characteristics of maker's new phenolic terminal blocks for electronic equipment.—Lenkurt Electric Sales Co., 1105 County Rr., San Carlos, Calif.
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Aluminum Conduit, Wire. New 16-page booklet AD-297 presents connection types, installation instructions, and capacities of aluminum conduit and wire.—Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh, Pa.
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Name Plates. New 4-page bulletin describes and illustrates maker's "Foilcal" name plates.—Miller Dial & Name Plate Co., 781 E. Washington Blvd., Los Angeles, Calif.
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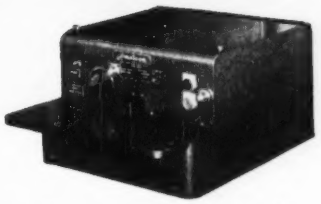

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MOTORS

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Frac.-hp. Motors. New 4-page issue Vol. 33, No. 5 of "Motorgram" features article on single-step control of fractional-horsepower motors.—Bodine Electric Co., 2250 W. Ohio St., Chicago, Ill.

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BALL BEARINGS

Miniature Ball Bearings. New 20-page illustrated Catalog 53-54 lists models, types, features, and applications of maker's miniature precision ball bearings.—Miniature Precision Bearings, Inc., Keene, N. H.

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Precision Ball Bearings. New 24-page Catalog 413 describes and illustrates maker's instrument ball bearings, production facilities, and typical applications.—Fafnir Bearing Co., New Britain, Conn.

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Precious Metals. New 24-page illustrated Bulletin R-12 gives description, properties, applications, and features of maker's precious-metal alloys for use in slip rings, commutator segments, resistance wire, and noncorrosive parts.—J. M. Ney Co., 71 Elm St., Hartford, Conn.

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Seamless Tubing. New 6-page bulletin presents plant facilities, products, and applications of precision seamless tubing.—Uniform Tubes, Inc., Level Rd., Collegeville, Pa.

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Shaft Design. New 27-page brochure "Techlopedia" discusses advantages and disadvantages of continuous operation, single-pass and multipass systems, and mathematical solutions to several shaft-design problems.—Techniflex Corp., Port Jervis, N. Y.

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Precision Screws, Hardware. New 10-page catalog lists types and prices of maker's screws, nuts, gear racks, etc.—R. Y. Ferner Co., Inc., 110 Pleasant St., Malden, Mass.

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Subminiature Blower. New 2-page brochure gives features, characteristics and dimensional data on maker's 1-in. cube motor and blower. Sanders Associates, Inc., 137 Canal St., Nashua, N. H.

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Subminiature Blower. New 2-page brochure gives features, characteristics and dimensional data on maker's 1-in.- cube motor and blower.—Sand-

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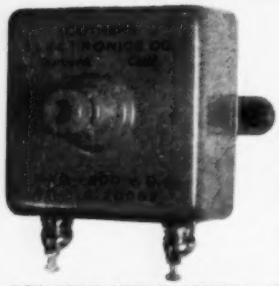

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ers Associates, Inc., 137 Canal St., Nashua, N. H.

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Oil-free Compressors. New 6-page illustrated bulletin presents design and cutaway drawings of maker's "Class ATCL Oilfreair and Oilfregas" compressors.—Pennsylvania Pump and Compressor Co., Easton, Pa.

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Air, Oil Coolers. New 8-page bulletin describes and illustrates maker's "inner-fin" oil coolers. New 2-page bulletin covers maker's water-cooled air aftercoolers.—Heat-X-Changer Co., Inc., Brewster, N. Y.

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Titanium Fabrication. New 4-page bulletin describes and illustrates process of titanium fabrication by—Brush Laboratories Co., 3714 Chester Ave., Cleveland 14, Ohio.

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Metal Cleaners. New 4-page bulletin describes, illustrates, and gives applications of maker's metal cleaners and compounds.—Man Gill Chemical Co., 2338 Canal Rd., Cleveland, Ohio.

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Lapping Machine. New 4-page Bulletin L-53 describes and illustrates maker's centerless lapping machines for precise microinch finish.—Size Control Co., W. Washington Blvd., Chicago 12, Ill.

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Resistance Soldering. New 2-page bulletin describes and illustrates maker's resistance-type soldering tools and heat controllers.—Vemaline Products Co., P. O. Box 222, Hawthorne, N. J.

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Instrument Covers. New 1-page illustrated bulletin describes maker's vinyl and rigid acetate instrument and equipment covers.—Bel-Art Products, 2209 Central Ave., Union City, N. J.

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Air Compressors. New 8-page Bulletin A-44 describes maker's "WGO-9 Oil-free" compressor, including dimensions, specifications, and applications.—Joy Mfg. Co., Henry W. Oliver Bldg., Pittsburgh 22, Pa.

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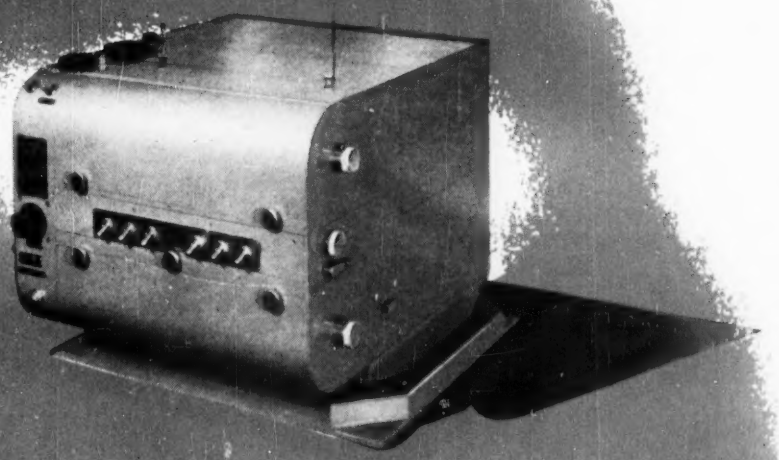

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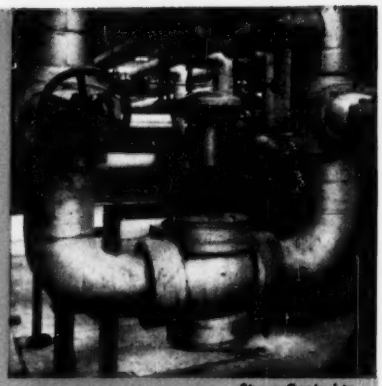

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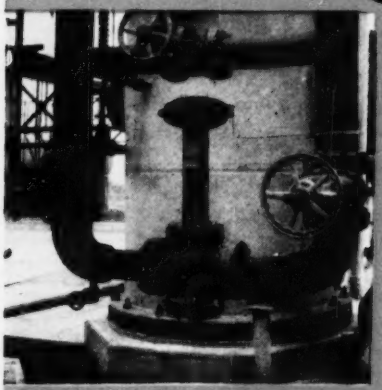

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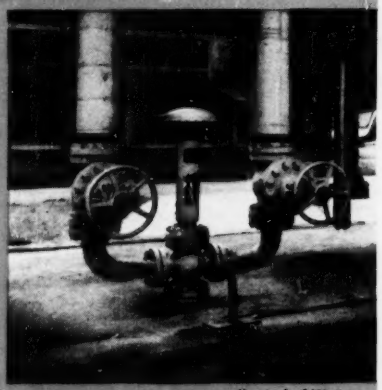

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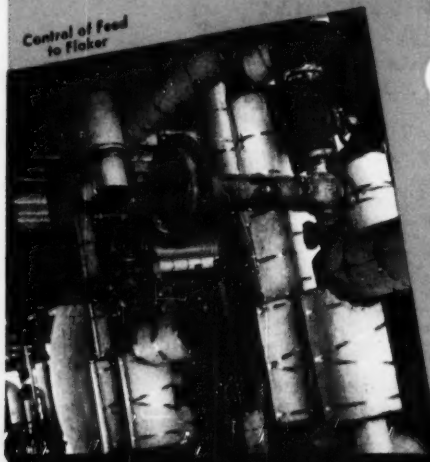

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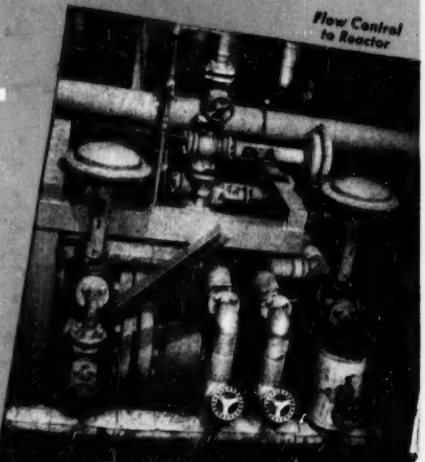

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